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SCIENCE AND PROSPERITY[1]

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I. SCIENTIFIC METHOD AND NATIONAL POLICIES

ONE of the fundamental laws of physical science is that inanimate nature, if left to herself, moves in the direction of chaos. This is a somewhat crude way of stating the Second Law of Thermodynamics. If the molecules of air in a room, for example, were all given uniform motions, and then left to themselves, their interactions with themselves and the walls would quickly change their velocities into the most random possible arrangement of motions, sometimes called the "Maxwell distribution of velocities."

In the field of human affairs many analogies may be drawn with this second law of thermodynamics. Human affairs, if left to themselves, also tend toward chaos. A business organization, if left without a guiding hand, becomes a disorganized business. A farm, if left to itself, becomes a wilderness. An economic policy of "let nature take her course" leads inevitably to economic chaos. A political policy of inaction can lead nowhere but toward anarchy.

[1] Address before the American Association for the Advancement of Science in Berkeley, June 21, 1934.

It is a significant fact that, in physical science, only one way has ever been suggested by which the tendency toward chaos can be circumvented. In slang phrase, there is only one way to "beat" the second law of thermodynamics. This way is by the exercise of intelligence in carrying out a planned policy. It was Maxwell who showed how this might be done in the case of molecules of a gas through the agency of a hypothetical intelligent being, who has been dubbed "Maxwell's demon" and who operates as follows to separate the fast from the slow molecules of a gas, which in nature remain mixed together.

Imagine a partition dividing the room into two parts and provided with a small opening just large enough to let a molecule pass through. Over this hole is a tiny trap-door operated by Maxwell's demon. Whenever he sees a very fast molecule approaching from one side he opens the trap-door and allows it to pass through. Similarly, whenever he sees a very slow molecule coming from the other side, he lets it pass through. So, after a while, he has separated the fast from the slow molecules, with the partition

dividing them. Thus, contrary to the second law of thermodynamics, he has substituted a systematic for a chaotic distribution of molecules and has thereby created a store of energy, because the fast molecules on one side are at a higher temperature than the slower ones on the other.

The analogy here with human affairs is apt. It is only by intelligence, creating and carrying out a plan, that a business, a farm or a government can be made productive, instead of degenerating into disorganization and impotence. In particular, we may draw an analogy with pressing problems of federal administration: without debating the pros and cons of details of any particular program, we can subscribe heartily to efforts of the Federal Government to introduce intelligent planning into national affairs. When a prominent New Dealer defended the "Brain Trusters" by asking what other part of the anatomy the country would prefer to be run by, he had in mind the facts which I am here pointing out by scientific analogy. By this analogy we may call the Federal Government the "Maxwell demon" of America, striving, by intelligent operation of economic and legislative controls, to bring order and power out of the chaos into which the country would necessarily drift in the absence of adequate intelligent control and guidance.

It is not an easy thing to introduce control and guidance. Individuals like to have independence; business organizations resist control; labor groups do not take kindly to the imposition of regulation from without; yet we must realize that society, like a gas, is chaotic and powerless if its human molecules, like gas molecules, have complete independence. Civilization consists in giving up a certain amount of individual freedom and irresponsibility in favor of group responsibilities and relationships which are socially more beneficial. I take it that our nation is now in the throes of becoming a little more civilized. Perhaps since this ascent from chaos is dependent on the use of intelligence, it is not going too far to say that the agonies of the past and present months are the natural accompaniments of a national effort at constructive thinking—said by psychologists to be a rare and difficult process even in individuals.

We have excellent illustrations of attempts to do these things in the past and present federal administrations. President Hoover, like a good engineer, started out to ascertain the facts, through a group of fact-finding commissions such as the one which completed the great report on social trends. He planned, from a study of these facts, to discover those aspects of our social, economic and political life which were most in need of attention and to direct his great energy toward their improvement along the lines of a well-founded program. It was an intelligent scientific approach to his problem, but, unfortunately, political conditions and the sudden breakdown of our unstable economic system (which was the accumulation of preceding years of unintelligent enjoyment of a fools' paradise) prevented progress of this program beyond its initial stages.

President Roosevelt also shows something of the spirit of the scientist in that he is attempting by theory and by experiment to develop a better economic and social program for the nation. We see this attempt in such agencies as the National Recovery Administration, the Agricultural Adjustment Administration, the National Planning Board, the Business Advisory and Planning Council, the Tennessee Valley Authority, the Science Advisory Board, the Federal Aviation Commission and a score of other bodies.

We see the experimental scientific method in the President's realization that much of what is done is of the nature of social experiment in which some features will be found to be unsuccessful and will be dropped and the problem will be tackled in another way, whereas other features will have proved to be successful and will be continued and developed further. Every scientist knows that this is the way of progress if wisely carried out. He also knows that some experiments inevitably will fail, for if the successful outcome could be predicted with certainty from the beginning, they would not be experiments at all and would add nothing to our present knowledge or development.

"Letting nature take her course" was listed above as one of the paths to chaos. Yet there is a very fundamental truth in the minds of some people who express their economic philosophy in this phrase, namely, that experimenting or maneuvering, to be successful, must be directed to take advantage of natural laws and not to run counter to them. The achievements of science come by the intelligent, skilful utilization of established laws of science. Similarly, experiments in human affairs will be successful if they are planned in accordance with, and not contrary to, basic social laws. If, as is unfortunately so often the case, we do not yet know what these laws are, then the "trial and error" method is the only recourse. The success of this method depends on a combination of knowledge, judgment, skill and luck. The present experiments in social adjustment lie somewhere within the boundaries of this paragraph.

Favorable to the success of these new social experiments is the fact that the people have had such a rude shock as to have awakened them from their complacent acceptance of the old order, which was suited to the simpler life and undeveloped natural resources of our expanding pioneer days, but which broke down under the growing complication and competition which necessarily followed modern technical progress and the final complete occupancy of the country.

The people generally realize that something was wrong, and are in a mood to support well-directed effort toward fundamental improvements. Opposed to the experiments may be those who personally suffer in the readjustments, or who do not trust the intelligence or motives of the present experimenters, or who are chiefly impressed with the unsuccessful rather than the successful experiments, or who would await more recovery before making bold experiments, or who are just naturally so conservative as to deplore departure from the "good old times." To these latter ones, however, I would point out that the old régime was not good, as proven by its disastrous debacle, and that a return to it would be as silly as for a scientist to repeat an experiment which proved unsuccessful.

II. Science and the Standard of Living

Let us pass, for the moment, from consideration of the scientific method as applied to national problems to the more specific application of science itself to public welfare. I will introduce this by describing one particular example, taken from electrical science.

It is just over a hundred years ago that Michael Faraday in England and Joseph Henry in America discovered the principles of electromagnetism which underlie most of our present electrical science and industry. Before them the few electrical and magnetic phenomena which were known were only scientific curiosities.

Joseph Henry started out as a young man in Albany, New York, to be an actor. He organized a theatrical troupe, wrote plays and was well started on his career when he was taken sick. While recuperating, a friend loaned him a book on natural philosophy, which raised and discussed such questions as: "Why do stones, when thrown in the air, fall back to the earth?"; "Why does the flame of a candle point upward?"; "If the candle were pointed downward, would the flame point downward and, if not, why not?" These questions so aroused Henry's interest that he forsook the stage, entered the Albany Academy to study science, became its science teacher, then professor of physics in Princeton University and finally director of the Smithsonian Institution in Washington. Many interesting stories can be told of his building of the first powerful electromagnet; perhaps the first telegraphic signal set; certainly the first wireless set—used by his wife to call him to meals from his laboratory; of his use of students to measure induced high voltages by seeing how many of them in a row he could shock. But his great discovery was the phenomenon of electromagnetic self-induction.

Simultaneously, in England, Michael Faraday was carrying on experiments in the Royal Institution through which he discovered electromagnetic mutual-induction between separate electrical circuits. It is said that the King once asked him, "What is the use of these experiments?", to which Faraday replied, "Your Majesty, of what use is a baby?" Again, when the Prime Minister visited his laboratory and asked the same question, Faraday is said to have replied, "My Lord, some day you can tax these things." How true this turned out to be can be amply testified to by any officer of a present-day public utility electric company.

The story of the electrical inventions of Thomas Edison, but recently dead; of Elihu Thomson, still living; of the more recent discoveries and inventions of Fleming, Coolidge, Kettering and a host of others is too well known to need telling. The point is that within one lifetime the entire electrical industry has grown up; most of it has come relatively recently; and there is in sight practically no limit to the possibilities of its future development.

Most of the basic discoveries have been made by professors in educational institutions, spurred on to their investigations by insatiable scientific curiosity. Most of the rest has been done in industrial laboratories, especially recently, and governmental laboratories have played an important rôle, especially in fixing standards of measurement. The industrial laboratories have taken the lead in developing useful applications of the discoveries. Here and there have sprung up inventive geniuses. All this work has brought enormous returns to the public. I will enumerate a few of them:

(1) Electricity has been found to be basic to the understanding of the structure of matter and of natural phenomena.

(2) Electricity has transformed modern life through its use in wire and wireless communication, lighting, transmission and application of power, household appliances, radio broadcasting, cinema, control of machinery, medical applications such as x-ray, railways, essential parts in automobiles, location of mineral and oil deposits, metallurgical and chemical processes, navigation, etc. These things have contributed mightily to man's safety, comfort, power and interest in life.

(3) Electricity gives employment to some millions of our people. For example, in electric manufacturing, distribution and operation of electric machinery, light and power, 1,035,000; in radio manufacture, distribution and servicing, 94,000; in motion pictures, 290,000; in the telephone industry, 357,000. If we take activities not wholly electrical but dependent upon electricity we have many more, such as 1,573,000 in the automobile industry (manufacture, distribution and servicing). It is probably no exaggeration to say that 10,000,000 people in this country are continuously dependent for their support on the results

of progress in electrical science. (Figures mostly from 1930 census.)

(4) As Faraday predicted a hundred years ago, electricity pays taxes.

We must admit that the public has been well repaid for whatever part it may have taken in providing the opportunities whereby the creative scientists, engineers and inventors were enabled to produce the present stage of electrical development.

Now this recital would not be so significant if it were an isolated instance; its significance lies in the fact that it is but one of hundreds of instances, some of major and some of minor magnitude, but all of which lead to the same conclusion. An equally impressive story could be told of the development of chemistry and its importance in our modern life. The same thing could be done in medicine or agriculture. We sometimes think of steel as the product of an old and rather primitive art, digging, smelting and hammering; yet a bulletin was prepared a few years ago which listed some twenty laboratory discoveries, without any one of which the modern steel industry would have been impossible.

The same conclusion can be reached by considering the engineering arts. Civil engineering, dating from the earliest times when men made paths and homes, has for its object the making of the earth a convenient place on which to live and move about. Mechanical engineering has to do with increasing man's power and the convenience of its application. When the Egyptian developed a mechanical water wheel to lift water from the Nile to irrigate his fields, he did not complain about technological unemployment because the water wheel had relieved him of the necessity of lifting the water by hand; he used his new device to increase his crops and his spare time and profits to build a better home and to devote himself to more cultural pursuits than carrying water. So it is all through the field of engineering, whether it be civil or mechanical, or the newer types of electrical, chemical, automotive, aeronautical, refrigeration, agricultural or mining engineering. All these have given man comfort, power and opportunity. Just as old civilizations were limited by their tools of stone or bronze and therefore described as the stone age or the bronze age, so our civilization is epitomized by our progress in the engineering arts. These are prepared to advance as never before if given opportunity. It is inconceivable that their advance should not be encouraged unless, fainthearted or shortsighted, we wish our civilization to stagnate or go backward.

In thus emphasizing the importance of science and engineering to civilization I am not unmindful of the fact that civilization should not be measured by its material features and I realize that the chief end of man is not material productive power. But I am mindful of the fact that these material things create a possibility for doing and enjoying the finer things of life. With all due respect to the genius of Aristotle as one of the great creators of civilization, it is not without significance that he had the services of more than 10,000 research assistants, provided him by King Alexander, who brought him information from all parts of the known world. Nor is it without significance that the great advances in civilization were made by peoples whose drudgery was done for them by slaves or serfs—the Greeks, Romans, Egyptians and the sixteenth century English. To-day we have done away with slavery. In its place we are served by the products of science—by mechanical power equal to the work of fifty slaves for every man, woman or child in the United States. It is this which has created our so-called high standard of living, which has given us our time for education, our insurance or pensions for old age, our vacations, our limited hours of labor. If developed and managed properly, it is this which can give every person in the country such opportunities for the finer things of life as were never before enjoyed even by the favored few.

III. Pressing Problems Challenge Science

We pass now to a brief consideration of a few of the national problems which urgently require attention, in order to see if science can make a contribution toward their solution.

(1) Unemployment still grips some 10,000,000 of our population. A paternal government may care for them at the expense, by taxation, of those who have an income, or it may give them work by forcing a division of available work among all people capable of performing it. These are socially necessary relief measures if no more permanent cure can be found. Necessary in an emergency, they become socially dangerous if carried too far or too long. The permanent cure is to provide more employment. It is here that science can help, as amply proven by the past experiences cited above, by creating new industries to provide new things that people want or by creating improved equipment or processes which will render obsolescent old equipment and thereby maintain a demand for new.

A difficulty with this cure is that it requires time, and therefore foresight. It may be years after a scientific discovery is made before the inventive idea or the combination of need and knowledge or the perfection of a method for applying it usefully brings it to the point of providing employment. Scientific developments can not, like the tricks of political demagogues, be pulled out of a hat. It would require a very rare type of far-sighted statesmanship on the part of political leaders to urge

financial support of creative science in the present for the sake of the national welfare at some future date. Yet the record of past events shows that no other known investment is likely to pay such large future dividends. Kettering saw this when he wrote, "The present troubles are not so much due to over-production of goods as to under-production of new ideas." Hoover saw it when, as Secretary of Commerce, he stated that this country was in danger of industrial stagnation because of its failure adequately to advance the sciences on which future industrial developments must be based. The National Academy of Sciences saw it when it attempted to raise from industrial organizations a large fund for research in pure science on the grounds that such support by these organizations was both the payment of a debt to science and an investment for the future—an attempt which was wrecked by the depression after coming within sight of the goal. The British saw it when, in spite of post-war financial troubles, they made a large government grant to aid the scientific work in their leading institutions. Germany, until perhaps recently, has seen and acted on it. Russia, though inexperienced, is bending every effort toward it. Japan has made it a national policy for years, and is now drawing dividends on it. What our government is doing about it I will mention later.

(2) Natural resources in land, minerals, timber and water power are at the root of our national life. Their wise use and conservation are basic to any far-sighted planning. In some aspects, they present problems which can not be passed by with thought of letting the future take care of itself, but are pressing for solution right now.

Take, for example, land use. Just how serious is soil erosion? In how many years, if unchecked, will it bring about a desperate condition of land sterility? How can it be controlled and how expensive and effective will this control be? Again, scientific study has recently shown that, if the number of trees per acre is reduced below a certain minimum in the yellow pine belt just east of the Cascade Mountains, then the ground water level drops and the country becomes a desert. Just what are the facts, and what should be the government's policy in view of them? Again, the great Mississippi River Valley used to include much lake and swamp land which has been drained to provide fertile farm land. Now a large part of the rainfall is run off in these drains to the streams and flows away, with the result that the ground water level is steadily falling and the climate is generally drier and warmer. What should be done about this? The California water problem is too well known to require discussion. In many parts of the country climatic conditions and soil are such as to cause repeated crop failures, with recurring burdens thrown on the country for relief. Should such sub-marginal lands be repossessed by the government and, if so, on what criteria should the selection of such lands be based?

Similarly, in minerals, we find no clear-cut national policy. Tariffs may operate one way, NRA codes another, state and federal taxes still another as regards such basically important considerations as conservation or an economically planned production program.

Some of these matters are now receiving governmental consideration. It is highly important that policies should not be determined principally on grounds of political expediency, but on a sound economic policy based on an accurate knowledge of the facts—which it is the business of science to provide. Thus in this field the national welfare calls for scientific study and for national backing of such study.

(3) Hereditary weaknesses, both mental and physical, constitute a terrific annual drain on the happiness and on the finances of the country. They present a tremendous challenge to science, a challenge which I believe will ultimately be met. We need to know in what respects these weaknesses are hereditary and in what respects they are individual accidents. We need to know if and how they may be cured. If incurable, and hereditary, the welfare of the race requires their elimination, perhaps by some such means as have been found successful in repressing undesirable or developing desirable physical and mental traits in domesticated animals. Much scientific work has been done in these lines, but only a beginning has been made. For example, I am informed that it is only within the last year that there has been found a definite physiological disturbance associated with the most baffling kind of insanity.

Such controls as are here suggested will be found unpleasant to contemplate by many people. But think, on the other hand, of the terrible unhappiness of defectives and their families; remember that their number runs into the hundreds of thousands; remember that they constitute one of the greatest drains on our economic resources. If science can find effective means to cure such cases or, if incurable, to prevent their occurrence, this alone would justify all the scientific work that has ever been done. To be sure, education and probably legislative action will also be required to complete such a program, which would fail without supporting public opinion. But science must do its part first. Legislative action not based on thoroughly established scientific findings would probably do more harm than good.

(4) Sickness, despite the wonderful advances of medical science, still remains as a challenge, continually reminding us that the job of science in this field is incomplete. The annual toll paid to physi-

cians is enormous and is a double economic loss (except to the physician); first, because the patient pays for something which is no gain over what should be his normal healthy state; second because, while sick, he is a social parasite.

The great challenges here are to develop preventive medicine and to find curative treatments for the few outstanding ailments which still baffle medical science. The goal is the continual maintenance of every man's highest level of physical and mental fitness.

(5) Crime presents abundant features to engage the attention of scientists. The physical scientist can develop better means of crime detection; the medical scientist and psychologist can find better means of treating the criminal to subdue his vicious tendencies; the social scientist can study those aspects of social environment which are conducive to right or wrong living and point out desirable reforms; the educator has his job of implanting sound habits of character. It is too much to hope that the devil will be banished from the face of the earth, but science can certainly help to reduce the number of his followers.

To this list might be added many more items. I would suggest, as a stimulating and interesting exercise for any scientist, that he form the habit of analyzing important social, economic or political problems, as they come to his attention in reading or otherwise, for the purpose of inquiring at which points science can usefully be brought to bear on these problems. If all our scientists were to do this, the most important step toward their scientific solution would have been taken.

IV. How Can Usefulness of Science be Increased?

Scientific work in this country is supported chiefly by four agencies—the government, the universities, industry and private philanthropy.

The Federal Government devotes about one half of one per cent. of its regular budget to its scientific bureaus. Most of this amount is spent for routine operations, such as testing and accumulation of data. Much of the rest goes into research work, some of which is excellent, but which is definitely restricted to certain particular fields. This scientific work is highly important to our national functioning. It is not, in my opinion, done under conditions most advantageous for the discovery of new phenomena or laws, or for the development of new industries, nor have these been its objectives. The Federal Government also makes small grants to land-grant colleges primarily to assist in their educational work, and in some instances to support experimental work, particularly in agriculture.

The state governments support the great system of state universities, where some of the finest scientific work in the world is being done, but often where such work is only tolerated by the authorities or is supported solely for its value in the educational program of the institution and without consideration of its inherent value to the public.

The universities, from the earliest times, have been the great productive centers of scientific research, and doubtless will so continue, since they offer uniquely favorable advantages of a wide variety of facilities and of cooperating experts, they have continuity, and their activities are not restricted into narrow utilitarian channels. No other organizations have such a continual supply of new blood and new ideas, brought in by the ambitious, exuberant youth in staff and student body. They have a great tradition of intellectual activity and freedom, from which springs originality.

Industrial laboratories, within the last generation, have come to take a very prominent and productive part in scientific research. They have certain advantages, such as large financial support for research which promises to yield financial profits. On the other hand, they are necessarily much restricted to such work as shows promise of relatively quick returns and, hence, big, new and unexpected things are not so likely to be discovered there. It is one of the paradoxes of past scientific history that most discoveries which have proved to be practically valuable were not made in the course of a search with such an objective. The unique field for industrial laboratories is in the application and adaptation of scientific phenomena, wherever discovered, to the objectives of the particular industrial organizations which maintain these laboratories. It is, in a sense, paradoxical that these industries, which stand to be the first gainers from scientific progress, can not from self-interest support pure research on a large scale under present conditions. The reasons are obvious:

The results of any program of pure research are uncertain as to their nature, time and importance. In the Research Laboratory of the Bell Telephone Company, for example, the net practical result of a year's work by a hundred scientists may be nil; or it may not be of commercial value until a dozen years later, and then perhaps only in combination with some other results from the General Electric or Westinghouse Laboratories; or it may turn out to be valuable to the steel corporations or the chemical companies rather than to the telephone company; or it may be seized upon and exploited by pirating companies who have had no burden of research expense. Theoretically, our patent laws should take care of these latter difficulties; practically the situation is too complicated and the laws are too antiquated, inadequate and costly to enforce. For example, the issu-

ance of a patent by our Patent Office carries practically no presumption that the patent is valid, and the establishment of validity is left for future litigation in the courts. This situation arises from a combination of factors, such as the enormous number of patents, the antiquated procedure in securing patents and the inadequacy of pay and tenure for highly qualified men on the staff of the Patent Office. The patent law was designed to create a temporary monopoly in order to encourage development and production, but it did not anticipate modern trends of invention into the complicated fields which require the control of many patents in order to produce a product. The court before which a patent case is tried is not provided with disinterested technical advice, with a result that the trials are long and expensive and their outcome does not always reflect the merits of the case. This whole situation is vastly in need of clarification, but meanwhile the industrial laboratories are doing an efficient job of industrial development and relatively little research on a wider base than that of their immediate practical interests.

Private philanthropy has played a uniquely large rôle in the scientific work of this country, in the endowment of universities, the building of special research institutes and the establishment of the great foundations. One hundred twenty-nine such foundations are said to exist in America. Seven of these foundations have already distributed more than $280,000,000, of which a considerable portion has been for support of science. A very rough estimate is that perhaps one fifth of the total amount has gone into research, excluding the very important fields of medicine and public health. These foundations are so well understood as to require no comment. I can not refrain, however, from noting that the contributions to human welfare, made by these foundations, have involved altogether but the expense of one battle fleet, or less than one tenth of last year's appropriations for emergency public works, and I would raise the question as to whether such examples do not suggest a lack of balance in the distribution of government expenditures which should be remedied.

Granting that the national welfare demands increasingly effective scientific work, the practical question is, "How can this work be supported?" The increasing control of business by government plus the tendency toward a more uniform distribution of wealth will probably reduce the magnitude of those large private bequests and altruistic foundations which have been so peculiarly the backbone of American enterprise in science and other fields. The general burden of taxation and the limited interests and responsibilities of individual states make it unlikely that the state governments will shoulder the primary responsibility of supporting scientific work. The problem is essentially national in scope; the public is the ultimate beneficiary, gaining or losing according to the degree of success of the work. Should not the public, therefore, contribute at least a large part of the necessary financial backing? Such public support of course means support through the Federal Government, ultimately through taxation. I further believe that, if this were done and wisely executed, it would prove to be in the front rank among governmental undertakings in the ultimate beneficial returns to the public per dollar expended.

Of equal importance to the securing of funds is the problem of their efficient administration. Money can be wasted faster in so-called research by placing it at the disposal of uninspired groups or hack-work programs than in any other way that has the guise of respectability. No formula, organization chart or administrative dictum can produce scientific progress. Perhaps the worst way to carry on research is to distribute funds according to some formula such as that followed in the support of land-grant colleges, $50,000 to each state in the Union or so much to every research laboratory. Almost as bad would be the pouring of funds into a centralized research bureau and saying, "Let there be research." Scientific progress can be gained only through securing the happy combination of scientists who have ideas with facilities for carrying them out. The job of administering funds for research is essentially to bring about such combinations.

I believe that the best method for administering funds for research is that which has been developed over a long period of experimentation and training through the great foundations, such as the Rockefeller Foundation and the Carnegie Corporation. They have been experimenting to find the most productive ways of administering funds for research. As a result they have trained large numbers of scientists through service on boards and committees, who have studied the needs and opportunities throughout the country with a minimum of overhead expense and a maximum of results. If large funds should become available for research this experience could be effectively used. These considerations would point to the National Academy of Sciences and the National Research Council as the natural advisory bodies in any large program of public expenditure for science. These bodies have status in the government through their charters and by executive orders, and they include representation from all important scientific and engineering societies. They have had more experience than any other similar groups in the country in the administration of funds for research.

In conclusion, I must confess to considerable doubt as to the wisdom of advocating federal support of

scientific research, not because of any doubt as to its value or logic, but because of insidious dangers which are perhaps too obvious to require elaboration. If government financial support should carry with it government control of research programs or research workers, or if it should lead to political influence or lobbying for the distribution of funds, or if any consideration should dictate the administration of funds other than the inherent worth of a project or the capabilities of a scientist, or if the funds should fluctuate considerably in amount with the political fortunes of an administration or the varying ideas of Congress, then government support would probably do more harm than good, for large support by government would tend to discourage the support by private philanthropy which has been the backbone of our scientific progress in the past and which will doubtless continue unless discouraged.

On the other hand, if government support of science were undertaken on an adequate scale and administered with the skill and experience that have already been developed in the handling of minor funds for science, such a program of federal support would certainly be a sound national investment, would be an uplifting intellectual and social influence and might well mean the difference between prosperity and economic catastrophe at no very distant date.

In this address I have raised certain questions which have many aspects and whose proper answer I do not know. They are questions, however, which challenge constructive thought and it may be that their wise solution can be attained.

SCIENTIFIC EVENTS

BRITISH MUSEUM'S EXPEDITION TO EAST AFRICA

THE trustees of the British Museum, according to the London *Times*, have arranged an expedition to British East Africa to study the ecological relations of animal and plant life in different areas of high altitude. It is well known that the combination of a nearly vertical sun, high altitude and copious rain has resulted in extraordinary development of vegetation, plants known in temperate regions of the size of shrubs reaching the size of trees, but no intensive and systematic study has yet been made of these areas. It is intended to ascertain what insects assist in fertilizing the flowers of the giant lobelias and groundsels.

The leaders, Dr. F. W. Edwards, entomologist, and Dr. George Taylor, botanist, from the British Museum (Natural History) sailed from England recently and will be away six months, having about four months for their work. The East African Governments are taking great interest in the expedition. The exploratory work will be almost entirely in Uganda, and the government is helping in many ways by financial aid and the loan of transport, and by allowing certain of their officers interested in either insects or plants to join the expedition for some period of its work. The expedition will also be joined by Mr. P. M. Synge, of the University of Cambridge, as assistant botanist and photographer, and Mr. John Ford, animal ecologist, of the University of Oxford, as assistant animal ecologist; both of them are already in East Africa. Allen Turner, of the Coryndon Memorial Museum, will act as guide and assist in collecting insects in the Aberdare Mountains. Of the Uganda officials, Mr. E. G. Gibbons, of the Medical Service, will be assistant entomologist and act as camp steward for the whole period of the expedition; G. L. R. Hancock, of the Agricultural Service, will assist in the camp organization and in collecting insects and birds on the Ruwenzori Range; A. S. Thomas, of the Agricultural Service, will be assistant botanist during the expedition's work on Mount Ruwenzori, and W. G. Eggeling, of the Forestry Service, will spend about a fortnight with the expedition as assistant botanist. Mr. J. F. Shillito, of the Nyakasura Mission School, Fort Portal, will accompany the expedition as guide and assistant collector on the northern side of the Ruwenzori Range.

The leaders were expected to arrive at Mombasa on October 19, and after completing their arrangements they and the remainder of the party, who were to join the expedition at Nairobi, would spend the last week in October in the Aberdare Mountains in Kenya Colony. Their next objective is the Mufumbiro Range in the Birunga Mountains, where they will stay two or three weeks. In December they will return northwards and stay on the southern side of Mount Ruwenzori until the end of the month. At the beginning of January they will proceed to Fort Portal and stay on the northern side of the Ruwenzori Range until nearly the end of the month. On the way back to the coast they will spend three or four weeks collecting on Mount Elgon, and some of the party will proceed to the isolated peak of Moroto if conditions are favorable. The leaders expect to return from Mombasa to England on March 9.

RADIO ECHOES

THE *Technical News Bulletin* of the National Bureau of Standards reports that special signals are being transmitted from two European radio stations for the study of long-delay echoes. The signals and

the whole undertaking are adapted to the participation of persons all over the world who have high-frequency receiving sets, no technical training being required. Long-delay echoes are a most surprising and baffling phenomenon. J. Hals was listening in Norway, one day in 1927, to telegraphic signals from station PCJJ in Holland on a frequency of about 9,600 kc/s. Some of the signals were followed, after about 3 seconds, by a faint echo or reproduction. Echo signals occurring one seventh of a second after an emitted signal had been well known, being due to the reception of waves that had traveled all the way around the earth. But the discovery of echoes after a materially greater interval than a seventh of a second immediately raised the puzzling question of where such an echo could come from.

The phenomenon has been verified in a few scattered observations by Dutch, British and French engineers. Echoes have been heard from 1 to 30 seconds after the emitted signal. Not enough is known, however, to determine what causes the echo signals nor how they are propagated. Two theories have been proposed. One, by Dr. C. Størmer, of Norway, is based on the assumption that there are streams of electrons in space some hundreds of thousands of miles out from the earth's equator, converging in a vast toroid upon the magnetic poles of the earth, and accounting for the aurora borealis or northern lights. Dr. Stormer supposes that the signals are reflected from these electron streams in space. According to the other theory, advanced by Dr. B. Van der Pol and Professor E. V. Appleton, these echoes are due to a slowing up and reflection of the waves by a peculiar distribution of ionization in the very high levels of the ionosphere (that portion of the atmosphere 65 miles and more above the surface of the earth which is responsible for all long-distance radio transmission).

The British Broadcasting Corporation through its magazine, *World-Radio,* and with the aid of Professor Appleton, has inaugurated a worldwide endeavor to learn more about these long-delay echoes. Special emissions are provided from two high-power, high-frequency stations to facilitate observations by anyone who cares to listen with a high-frequency receiving set. Listeners in all parts of the world have been enrolled in the endeavor, over 10,000 of them in Great Britain. It seems likely that information of unique value to science will result, and an orderly explanation of the curious phenomenon developed, when definite data are secured on the frequencies and the times of day and season at which these echoes occur, their intensities, the area over which a given echo is heard, their relation to magnetic storms, sunspots, etc.

Dr. J. H. Dellinger, chief of the radio section of the National Bureau of Standards, would be very glad to have any successful reception of long-delay echoes in the United States reported to him, and will relay the information to the British authorities who are coordinating the investigation for the world as a whole. Observers should give the identifying letter of the signal observed, the time to the nearest second at which the direct signal was heard, the time to the nearest second at which the echo was heard, an estimate of the relative intensities of direct signal and echo, a description of the sharpness or apparent shape of the echo, and any pertinent information on interference, fading of signals, or other conditions of the observations.

Dr. Dellinger would be interested also in receiving reports on reception of long-delay echoes on any other stations, especially high-frequency stations in the United States. It may, on the other hand, be difficult to be certain of any echoes observed because of the lack of silent periods as in the special signals from the two European stations.

LOCAL HEALTH SERVICE IN RURAL AREAS

IMPROVED rural health standards, which are summarized in the Boston *Evening Transcript,* will be sought by the public health service in using a $1,000,000 grant allotted from the Federal Emergency Relief funds. Surgeon-General Cumming has issued regulations governing participation of the public health service in the establishment or maintenance of permanent local health services in rural areas.

The service will give financial aid through state health departments toward maintaining existing county or district health units when local funds available are insufficient. Also it will undertake establishment of new full-time rural health units, where needed, when local funds available are insufficient to meet the entire cost. It will not contribute to any project in which less than fifty per cent. of the cost is borne by state or local authorities, and where state or local authorities can meet more than fifty per cent. of the total cost of a project they will be expected to do so. The Federal service will not contribute to any project in which less than twenty-five per cent. of the total cost is borne by local authorities.

Under the regulations, the allocations for rural health maintenance will be made only where the county or district unit is under direction of a whole-time medical health officer whose training meets the requirements recommended by the joint committee on qualifications of county health officers and adopted by the conference of state and territorial health officers. The personnel of the unit must consist of not less than a

whole-time medical health officer, one public health nurse and a clerk.

The state health officers will submit to the Public Health Service a statement of the situation in each county or district recommended for assistance and will attach a proposed budget showing the distribution of funds from all sources and indicating the items required from the Public Health Service for the period ending June 30, 1935. The surgeon-general will then review these with discretion to approve or disapprove of any project submitted for consideration.

Quarterly reports will be required from state health officers to the Public Health Service for each project, showing the activities carried on by the unit and presenting a statement of expenditures incurred by the several participating agencies for the quarter.

Notices went out to state health officials on October 19, announcing that the allocation of funds could be made as soon as desired by counties needing assistance. There are now 550 full-time county units. The number in 1933 was 616 units. The first to be organized was in Yakima County, Washington, in 1911. The state health officials at that time asked the Public Health Service to aid in setting up an agency to combat typhoid fever. The unit has continued active since.

It is estimated that less than twenty-five per cent. of the rural population of the country has the benefit of full-time service at the present time.

EDWARD W. BROWNING'S BEQUESTS FOR PUBLIC WELFARE

BY the will of the late Edward W. Browning, of New York City, the income from his residuary estate, said to be over $5,000, will be divided into six equal portions and such portion be devoted each year as a prize for the results achieved during such year in the six classes or purposes outlined in the will which are to be known as the Browning Prizes. The classes are as follows: "The prevention of cruelty to children or animals, or the promotion of peace and international harmony.

"The spreading of the Gospel under Protestant auspices, either by distinguished example, effective teaching or exceptional service.

"The uplifting of the moral condition of the world, either by some direct and positive service or example to that end, or by the introduction or furtherance of methods most successful in decreasing vice, gambling, intemperance; or dishonesty and corruption in government and politics.

"The production of the most serviceable invention or useful discovery; or architectural improvement in fireproofing and sanitation or otherwise; or the most important work of art in painting, sculpture or literature.

"The most widely beneficial discovery or new method in medicine, surgery or in the prevention of disease.

"The increased production or improvement of fish, birds or animals; the conservation of forests; the irrigation of arid lands; the increase or improvement of crops, flowers or plants." The value of Mr. Browning's estate is said to be $7,000,000. The testament, dated in December, 1912, named as trustees of the prize funds Dr. Elmer Ellsworth Brown, formerly chancellor of New York University; Dr. Nicholas Murray Butler, president of Columbia University; Dr. John H. Finley, Robert T. Morris, M.D.; Dr. Henry S. Pritchett; The Rev. Henry A. Stimson, and the late Clarence H. Kelsey.

DEDICATION OF THE NEW ZOOLOGICAL LABORATORY AT BELTSVILLE, MD.

MORE than a hundred guests attended the dedication services on October 20 of the new Zoological Laboratory building which has now been completed at the Beltsville Research Center, Maryland. Dr. Maurice C. Hall, chief of the Zoological Division of the Bureau of Animal Industry, presided and several guests spoke briefly. Among the speakers were: Dr. Cooper Curtice, who was the first chief of the division and is now retired; Dr. Charles Wardell Stiles, who also served as chief of the division; and Dr. Albert Hassall, who until his recent retirement was assistant chief. These men discussed the early work of the bureau in research and procedures for the eradication and control of animal parasites, and stressed the possibilities which the new building and equipment provide for additional investigations.

Other speakers were Dr. Henry B. Ward, permanent secretary of the American Association for the Advancement of Science: Dr. W. E. Cotton, superintendent of the Bureau of Animal Industry Experiment Station at Bethesda, Md.; Dr. Lawrence A. Avery, superintendent of the new laboratory; and Earl C. Butterfield, the newly appointed superintendent of the Beltsville Research Center. Other guests represented the Johns Hopkins University, the Helminthological Society of Washington, the Smithsonian Institution and various branches of the Department of Agriculture.

The building cost $50,000 and contains thirty-one rooms. It will be used for experimental work in the control and eradication of parasites. Several other buildings accommodate small animals such as dogs, cats, guinea pigs, rabbits, chickens, pigs and others. The special equipment includes a variety of apparatus, a post-mortem room, refrigerator room, incinerator and library. The lots and pens outside these buildings are separated by double fences and ditches

to prevent contamination from other pens. Special equipment is provided also for the disposal of manure from pens where parasitized animals are being kept. There are also small oil moats, in some cases, to insure isolation of animals in certain types of experiments.

The laboratory building and other small buildings were designed by Dr. Lawrence A. Avery, who also planned the landscaping of the adjacent grounds in such a way as to utilize as much of the native topography and native shrubbery as possible. A ravine which lies at some distance from the buildings has been utilized by simulating a zoological park with pens and shelters for dogs that will be kept for experimental purposes.

RECENT DEATHS

DR. OTTO FOLIN, professor of biological chemistry in the Harvard Medical School, died on October 26, at the age of sixty-seven years.

A TELEGRAM from Eagle Lake, Fla., announces the death of Dr. Gilman A. Drew, until 1911 professor of biology at the University of Maine and resident assistant director of the Woods Hole Biological Laboratory from 1911 to 1926. Dr. Drew was in his sixty-sixth year.

DR. SAMUEL PARSONS MULLIKEN, professor of organic chemistry at the Massachusetts Institute of Technology, died in his seventieth year on October 24.

DR. WILLIAM CHITTENDEN LUSK, who for seventeen years until his retirement last June was professor of clinical surgery at the University and Bellevue Hospital Medical College, died on October 24 at the age of sixty-seven years. He was a brother of Dr. Graham Lusk, who died two years ago.

SIR JOHN AIRD, engineer of the great Assuan Dam in Egypt, died on October 20. He was seventy-two years old.

DR. RADÓ KÖVESLIGETHY, professor of cosmography and geophysics in the University of Budapest, died on October 12 at the age of seventy-two years. Professor Kövesligethy was a leading authority on seismology and was general secretary of the International Seismological Association from 1904 to 1916.

Nature reports the death of Professor Adalbert Fernau, director of the Institute for Radium Technology at Vienna, on August 30, aged fifty-six years.

ROSS ALBERT WELLS, since 1912 head of the department of mathematics and astronomy at Park College, died on October 8. A correspondent writes: "Professor Wells was a native of Ohio and received his education at Franklin College and the University of Michigan. Previous to his work at Park College he had served in the public school system in Ohio, was professor of mathematics at Bellevue College, and professor of mathematics and physics at Westminster College, Fulton, Missouri. He also served for several years on the staff of the summer school at the State Teachers College, Warrensburg, Mo. During the interval of 1920 to 1922, he was associate professor of mathematics at the State Normal College at Ypsilanti, Michigan. From 1918 to 1920, he also served as dean of Park College. He was a member of the Mathematical Association of America, the American Mathematical Society, the American Association of University Professors, and also was treasurer of the newly organized Missouri Academy of Sciences. Professor Wells was an exceptionally gifted teacher, and has made a definite contribution in the field in which he worked."

FRANK JULIAN SPRAGUE, inventor, consulting engineer of the Sprague Safety Control and Signal Corporation, died on October 25 at the age of seventy-seven years. Among Dr. Sprague's inventions are the modern trolley system, the multiple-unit system of electric railways and high-speed electric elevators. *The New York Times* writes editorially: "With Frank Julian Sprague has passed another of the brilliant group that Edison gathered around him in the brave days of the incandescent lamp when youth and imagination created electrical engineering. Office elevators, trolley cars, subway trains—Sprague left his impress upon them all. It was in London's smoky 'tube' that he conceived the idea of driving trains electrically. His opportunity came in Richmond, Va., where he gambled his last dollar on building a twelve-mile trolley road, a central power plant, forty cars with eighty motors and all the auxiliary apparatus, and this in the year 1888 when there were not a hundred motors in the world. The effect was immediate. The electric street railway was born. But it was the 'multiple unit' system of control that made him really famous. By placing motors on cars and lock-stepping them so that they could all be started and stopped at once by a mere turn of a handle, he made long subway trains possible. Had he lived but a few days longer he would have received the John Fritz Gold Medal for his achievements and thus become a member of a similarly honored group that includes Kelvin, Edison, Marconi, Pupin and Carty."

SCIENTIFIC NOTES AND NEWS

THE Nobel Prize in physiology and medicine has been awarded to Dr. George Richards Minot, director of the Thorndike Memorial Laboratory of the Boston City Hospital and professor in medicine at the Harvard Medical School; to Dr. William P. Murphy, of the Peter Bent Brigham Hospital and the Harvard

Medical School, and to Dr. George H. Whipple, professor of pathology and dean of the School of Medicine and Dentistry at the University of Rochester. The value of the prize is approximately $40,000.

The degree of doctor of laws was conferred on Dr. Warfield T. Longcope, professor of medicine at the Johns Hopkins Medical School and physician-in-chief of the hospital, on the occasion of the installation of Colonel Amos W. W. Woodcock as president of St. Johns College, Annapolis.

Dr. Arthur H. Compton, since 1923 professor of physics at the University of Chicago, this year George Eastman visiting professor at the University of Oxford, has been admitted as a supernumerary fellow of Balliol College.

Dr. The Svedberg, professor of physical chemistry at the University of Upsala, has been elected an honorary member of the German Colloid Society.

Dr. Carl Christensen, until his retirement curator of the Botanical Museum at Copenhagen, has been elected a corresponding member of the Field Museum of Natural History in recognition of "eminent services to the museum." Dr. Christensen has been instrumental in promoting the success of the joint botanical project of the Rockefeller Foundation and Field Museum to photograph type specimens of plants in European herbaria.

The Sir Gilbert Blane Gold Medal for 1934 has been awarded by the Royal College of Surgeons, London, to Surgeon Lieutenant-Commander T. C. H. Neil.

A dinner in honor of Professor E. G. Coker on the occasion of his retirement, after serving for twenty years, from the chair of engineering at University College, London, was held at the college on October 11. Lord Rutherford presided over a large gathering of the staff and former colleagues of the guest of honor. Tributes to Professor Coker were paid by the chairman and by Professor L. N. G. Filon. Professor Coker was afterwards presented with a check and a camera.

At Cornell University, Benjamin D. Wilson, '18, agronomy; Frank L. Fairbanks, '10, agricultural engineering; Clive M. McCay, animal husbandry, and Dr. Maurice C. Bond, '28, agricultural economics and farm management extension, have been promoted to professorships. Drs. Allan C. Fraser, '13, and Roy G. Wiggans, '19, have been appointed assistant professors in plant breeding. New assistant professors by promotion are Frank B. Howe, agronomy; Forrest B. Wright, '24, agricultural engineering; John P. Willman, animal husbandry; Dr. Floyd A. Harper, '32, and Lowell C. Cunningham, agricultural economics and farm management, and Kenneth G. Parker, plant pathology.

Dr. Kornel Ludwig Terplan, research professor of pathology at the School of Medicine of the University of Buffalo since 1930, has been appointed head of the department of pathology and bacteriology to succeed Dr. Herbert U. Williams, who retired recently.

Dr. Archibald B. Macallum has resigned after many years service as dean of the University of Western Ontario Faculty of Medicine, London. Dr. Frederick J. H. Campbell, associate professor of medicine, has been made acting dean.

Dr. W. J. Trjitzinsky, of Northwestern University, has become an assistant professor of mathematics at the University of Illinois.

The *Journal* of the American Medical Association reports that Dr. R. Fetscher, extraordinary professor of eugenics and biology as pertaining to heredity at the Dresden Polytechnicum, and Professor F. Dessauer, radiologist and ordinarius for medical physics at the University of Frankfort-on-Main, have been retired by reason of the new legislation.

Frederick D. Richey, associate chief, has been appointed chief of the Bureau of Plant Industry, in succession to Knowles A. Ryerson. Mr. Ryerson, who has been made head of a section of sub-tropical horticulture, will resume his earlier work with citrus fruits, avocados, dates and other tropical fruits. Mr. Richey has been associated with the bureau for more than twenty-three years.

Maunsell Van Rensselaer has been appointed assistant director of the Blaksley Botanic Garden of the Santa Barbara Museum of Natural History.

Dr. A. Richard Bliss, Jr., professor of pharmacology and dean of the School of Pharmacy of Howard College, Birmingham, Ala., has been appointed scientific consultant to the United Medicine Manufacturers of America, Inc.

Sterling L. Redman, who has been associated with the Central Scientific Company of Chicago for twenty years, during the past five of which he has served as its vice-president and sales-manager, has severed his connection with that company to establish a general apparatus and scientific supply business in San Francisco.

Dr. H. C. Thompson, professor and head of the department of vegetable crops at Cornell University, recently returned from six months' sabbatic leave. He visited several of the important vegetable growing areas and agricultural colleges in the South and West. Dr. Ora Smith, assistant professor of vegetable crops,

has returned to the university from Washington, D. C., where he has been carrying on investigations for the past seven months as horticultural representative for the Production Credit Division of the Farm Credit Administration. Dr. Smith traveled through most of the important vegetable areas of the country consulting with the officers of the Production Credit Corporations and Production Credit Associations.

W. J. BAERG, of the University of Arkansas, has returned from a two months' stay in Mexico. The trip was made for the purpose of studying tarantulas and other so-called poisonous arthropods.

DR. LUCY BOYD, of the department of botany of the University of Edinburgh, and lecturer in the Craiglockhart Training College, Edinburgh, Scotland, is spending a year in the United States. She holds the Rose Sidgwick Memorial Fellowship and is spending the fall months continuing a study of monocotyledonous seedlings in the department of botany at Connecticut College, New London. She will spend the balance of the year at Cornell University.

THE second Harvey Society Lecture will be given by Dr. William Cumming Rose, professor of biochemistry at the University of Illinois at the New York Academy of Medicine on November 15, at 8:30 P. M. The subject of the lecture will be "The Significance of the Amino Acids in Nutrition."

DR. W. D. BIGELOW, director of the research laboratories of the National Canners Association of Washington, delivered the fourth Wiley Memorial address on "Food Preservation in Relation to Public Health" at the opening session of the Association of Official Agricultural Chemists which met at Washington under the presidency of Dr. R. Harcourt on October 29. Dr. Bigelow was the first assistant chief of the Bureau of Chemistry, U. S. Department of Agriculture, under Dr. H. W. Wiley, "father of the Pure Food Law" and the first president of the Association of Official Agricultural Chemists.

PROFESSOR S. W. RANSON, director of the Institute of Neurology of Northwestern University Medical School, delivered the Weir Mitchell oration before the College of Physicians of Philadelphia on October 17 on "The Hypothalamus: Its Significance for Visceral Innervation and Emotional Expression."

AT the meeting of the Philosophical Society of Washington on October 27 Dr. Lyman J. Briggs spoke on "The Flight of the Stratosphere Balloon *Explorer*," and Dr. L. B. Tuckerman on "Technical Difficulties in Stratosphere Ballooning."

DR. HENRY C. SHERMAN, Mitchill professor of chemistry at Columbia University, lectured at the Medical College of Virginia at Richmond on October 12 under the auspices of the Virginia Section of the American Chemical Society.

DR. DEAN BURK, of the Office of Fertilizer and Fixed Nitrogen Investigations of the Bureau of Chemistry and Soils, delivered a series of lectures on "The Metabolism of Azotobacter" from October 22 to 31 at the Iowa State College under the auspices of the departments of soils, bacteriology and biophysical chemistry. While there Dr. Burk also delivered an address on "The Photosynthesis Problem in Wheat and Algae" before the Iowa State College Chapter of the Sigma Xi.

THE Smith-Reed-Russell lecture for October at the School of Medicine of George Washington University was delivered by Dr. Robert U. Patterson, Surgeon-General, Medical Corps, United States Army, on "The History of Yellow and Typhoid Fevers in the United States Army." The annual banquet of the society was held on October 23 and addresses were given by Dr. Charles Wardell Stiles, U.S.P.H. (retired) on "The History of Hookworm Diseases in the New World" and by Dr. Henry B. Ward, permanent secretary of the American Association for the Advancement of Science, on "Salmon Psychology." Emeritus professors and faculty members elected to honorary membership included Drs. Sterling Ruffin, Kerfoot Shute, Huron Lawson, William K. Butler, Buckner M. Randolph, Custis Lee Hall and Jacob Kotz.

THE department of botany of Iowa State College will commemorate on November 15 and 16 six decades of the modern era in botanical science with four symposia entitled, "Teaching General Botany," "Good Teaching," "Erosion Prevention Capacity of Plant Cover," and "Applied Botanical Research of Maize." Speakers from twelve different institutions and two departments of the Federal Government are to be present.

PREVIOUS awards from the Elizabeth Thompson Science Fund have been reported in SCIENCE, October 20, 1933, and earlier. Since the last report the following awards have been made at the meeting of February 2, 1934: to Laurence Irving, University of Toronto, $225 for the purchase, transportation and maintenance of seals to be used in an investigation of the mechanism for conserving the oxygen supply of the body in diving animals; and to Miss Eleanor Mason, Womens Christian College, Madras, India, for apparatus to be used in a study of metabolism in relation to race and climate. The trustees of the Elizabeth Thompson Science Fund meet ordinarily during the last ten days of the months of February, May and November. Applications for grants should be sent well in advance of the next meeting, to be

held late in November, and should be addressed to the secretary of the Fund, Dr. A. C. Redfield, 20 Divinity Ave., Cambridge, Massachusetts.

To promote more effectively the active national movement toward wild life restoration the area comprised by New England, New York, New Jersey, Pennsylvania and Delaware has been organized under the direction of Dr. Bertrand E. Smith, regional director, with headquarters at the Massachusetts State College at Amherst. This regional organization will operate under the Division of Game Management of the Bureau of Biological Survey. Dr. Smith will have general direction of the work of environmental control, the conservation and protection of wild birds and animals, including the activities under the Migratory Bird Hunting Stamp Act, the Migratory Bird Treaty Act, the Lacey Act and other regulations enforced by the division. He will have general supervision of the activities. It is planned to develop a well-rounded educational program in the region to acquaint the general public with the work of the bureau.

A SPECIAL committee has been appointed at the University of Wisconsin which will consider the use to be made of the income from the $450,000 bequest for medical and surgical research left to the university by the late Jennie Bowman. Members of the committee are President Glenn Frank, Dean Charles R. Bardeen, of the Medical School, and Dr. E. B. Fred, dean of the Graduate School. The committee has been instructed to report as soon as feasible. The groundwork for the cancer research center at the university has already been laid through the work of Dr. Michael F. Guyer, professor of zoology, and his assistants.

THE joint settlement of the estates of Dick S. Ramsay, former president of the East River Savings Bank, New York City, and Miss Ione May Spears, his principal heir, will yield about $1,000,000 for charitable and educational institutions. Among other bequests the Brooklyn Institute of Arts and Sciences receives about $450,000.

THE new laboratories of materia medica and pharmacology in the Department of Preventive Medicine at the Welsh National School of Medicine, Cardiff, were opened on October 12 by Sir William James Thomas, the donor of the building. In the evening, Professor G. Grey Turner, of the University of Durham, delivered the opening address for the new session.

WALTER ELLIOT, British Minister of Agriculture, on September 6 turned over the deeds of the manor house, farm and lands of the Rothamsted Experimental Station at Harpenden, to the Lawes Agricultural Trust, in the presence of a large gathering.

AN Associated Press dispatch reports that ten thousand elm trees in and near New York City have been attacked by the Dutch elm disease which threatens to spread to upstate New York next spring. $155,000 has been appropriated by the state which will concentrate this winter on holding the disease within the present infected zone, thirty-five miles from the City Hall of New York.

MORE than 30,000 photographic negatives of type specimens of plants preserved in European herbaria have been made under the joint project of the Rockefeller Foundation and Field Museum of Natural History, Chicago, which has been in operation for the last five years. Through Field Museum these photographs are made available to botanists generally in the United States and other countries. With them botanists are enabled to make determinations of plants which formerly would have required visits to Europe for exact identifications.

A SURVEY intended to measure accurately the density, nature and distribution of air-borne pollen in the upper atmosphere has been inaugurated by the Philadelphia College of Pharmacy and Science. It will be carried on over the Philadelphia metropolitan area and from Atlantic City seaward for twenty miles. The survey is made by airplanes, each plane being equipped with an apparatus for taking in measured volumes of air. The first flight was made on Thursday, September 20. These flights will continue during the rest of the 1934 hay fever season and throughout the season the next four years. During the balance of this season the apparatus for collecting the air samples will be elaborated and perfected. Apparatus for collecting the air samples was developed in the Philadelphia College laboratories under the direction of Professor Frank N. Moerk. General direction of the survey is in the hands of Dean Charles H. LaWall, head of the department of bacteriology and hygiene, while Dr. Henry K. Seelaus and Dr. A. H. Zifferblatt, of the Philadelphia College Laboratory of Immunology, are in immediate charge. Identification and counting of pollen grains and other biological aspects of the survey is being directed by Dr. Marin S. Dunn, head of the biology department. It is hoped to enlarge the scope of the work to include a count of dust particles and bacteria. The airplanes with which the survey is being conducted were made available by Richard Mark, a hay fever sufferer and a patient of Dr. Seelaus and Dr. Zifferblatt.

A CORRESPONDENT of the London *Times* reports that on May 25 a meteorite had been presented to the British Museum by the Government of Southern Rhodesia. The stone, weighing 58 pounds and 11 ounces, has since been received, and it is now on exhibition in the Central Hall of the Natural History Museum, South Kensington. The meteorite fell at

12:45 P. M. on March 7, 1934, in the Mangwendi Native Reserve, 40 miles east of Salisbury. A brilliant meteor (fireball) was seen, and three loud detonations followed by a rushing noise were heard. The detonations were heard over a radius of 50 miles. The natives said, "The sun came rushing from the sky and buried itself in the earth," and they called the stone "Miminimini," meaning "something to make you gape." In its fall it broke off the branches of a tree and made a hole 3 feet across and 18 inches deep in stony ground. The stone itself was broken by the fall. In addition to the main mass several small pieces were recovered, and the weight of the whole must have been about 60 pounds. But this could have been only a fraction of the original weight when the stone entered the earth's atmosphere at a height of about 100 miles. Travelling with an initial velocity of 20 to 40 miles a second, the intense heat developed by the resistance of the air melted and dissipated material from the surface, causing a rapid diminution in size of the stone and in its velocity. Fortunately, the stone was secured soon after its fall by the officers of the Geological Survey of Southern Rhodesia, and in the Survey Laboratories at Salisbury it has been submitted to a detailed and complete chemical and petrographical investigation. There it was found that it consists mainly of stony matter with small proportions of metallic nickel-iron (3.17 per cent.) and iron sulphide (trolite, 4.98 per cent.). The stony portion consists of olivine, enstatite and felspar, forming a compacted mass of minute broken fragments with curious rounded grains (chondrules). The new Rhodesian meteorite is the fifth largest stone in the collection.

DISCUSSION

THE MOTION OF GLACIERS

MANY persons who are not especially concerned with other topics in the field of glaciology are interested in the problem of the nature of glacial flow. Accordingly, it seems not inappropriate that there should be a notice in SCIENCE of a paper[1] which, if not conclusive on this question, does give the mature view of a specialist, competent in physics and mathematics, who has given a lifetime to the observational, experimental and theoretical study of glaciers, namely, H. Hess, of Nurnberg. Moreover, the paper referred to is one that will be seen in the original only by the few who pursue similar studies. Further, the representations of Hess are now very fully in accord with the views of the undersigned, published a number of years ago but not then generally accepted.

Although a variety of theories of glacial flow have been formulated, most have been rejected at once because they were completely out of harmony with well-defined characteristics of glaciers observationally determined. During the past thirty or more years the question has resolved itself into a controversial attitude between a large group which adheres to the idea that glaciers are essentially rigid crystalline masses and flow through some manner of shear motion and another smaller group that considers such motion to be of the nature of a plastic or viscous yield. The shear concept implies spasmodic motion; the single breaks perhaps very small indeed, but nevertheless intermittent. If, however, the flow is viscous there should be continuous yield.

Accordingly the adherents to the shear theory have sought to demonstrate its correctness by securing graphic records through clock-controlled mechanisms that would show irregular increases and decreases in the rate of flow at the terminal parts of glaciers. In this endeavor they have been successful, even to the degree of showing differential motion of adjacent sections of ice. It has, however, long been contended by the author of this notice that demonstrated shear motion in the surficial and terminal parts of a glacier is not to be interpreted as evidence of the true nature of the flow of the ice as a glacial mass. That contention, among other things, is now upheld also by Hess.[2]

In the papers[3] by the author of this notice it was argued on the basis of many different kinds of evidence, some observational from glaciers in Alaska, some from experimental work with ice, that a glacier consists of an outer and terminal crust of rigid ice, carried along and shoved forward by a core of interior ice flowing viscously under the pressure of the exterior shell and existing at essentially the pressure-temperature melting point of ice, a temperature which declines with depth (because of the increase of pressure) to the bottom of the glacier. The viscous flow of the interior ice results from the presence of a liquid film of salt solution surrounding and separating the glacier grains. This film acts as a lubricating medium to facilitate the movement of the grains one past the other. It has been shown mathematically that such differential movement of very slight amount between the crystals will suffice in sum to account for all ob-

[1] H. Hess, "Das Eis der Erde," Handbuch der Geophysik, Bd. VII, Lieferung 1, Berlin, 1933.

[2] *Op. cit.*, pp. 80–81, 92–93.

[3] O. D. von Engeln, "Experimental Studies and Observations on Ice Structure," *Am. Jour. Science*, 190: 449–473, 1915; R. S. Tarr and O. D. von Engeln, "Experimental Studies of Ice with Reference to Glacier Structure and Motion," *Zeitschrift f. Gletscherkunde*, Bd. IX, pp. 82–139, 1915.

served rates of glacial movement and it provides the continuous motion required for viscous flow.

Such exactly is the concept now set forth in Hess's paper. In the following quotations it is attempted to translate his German precisely as to meaning. "It has become more and more clear that the motion of glaciers is due solely to gravity and that the motion is to be considered comparable to the streaming of a very viscous fluid."—p. 79. (In all other paragraphs Hess uses plastic instead of viscous to characterize the nature of the flow.)

"Ice maintained at the pressure-temperature melting point is always a mixture of the fluid and solid phases of water."—p. 12. "Every increase in pressure brings about an increase, every decrease a reduction in the proportion of the liquid phase."—p. 12. "The melt water present will concentrate preferably (chiefly?) on the boundary faces of the crystals of which the ice is composed."—p. 12. "Salts (of various kinds) are present in small quantities and surround each crystal with a thin film of material that melts more readily (at lower temperatures) than the inner parts of the crystals."—p. 6. On pages 46 and 47 data obtained from borings are tabulated to show that between 18 m and 148 m the temperatures of the ice of the interior of the *Hintereisgletscher* are, at every depth, approximately (20 per cent. lower) at the pressure-temperature melting point, and the excess of lowering is ascribed to the existence within the glacier of pressure due to motion in addition to the vertical pressure of the overlying ice. "A glacier flowing under heavy pressure must be regarded as a water-ice mixture."—p. 59. "The melt-water content of flowing ice constitutes a kind of lubricant."—p. 12. At the sole of the glacier "the ice under heavy pressure is especially plastic because of the marked increase of the fluid phase, hence ground crevasses are rather improbable. Such crevasses are not even to be expected at the foot of an ice fall where the ice has, toward the surface, a concave curvature."—p. 58. Hess points out in parentheses that as late as 1929 he entertained the contrary view, *i.e.*, that such ground crevasses were possible. This notation is important because it indicates that Hess has only recently been fully converted to the plastic-flow theory of glacier motion.

Hess summarizes (in part) as follows: "Because uniform pressure develops a small volume of water on the boundary faces of the crystallographically, irregularly oriented structure of grains (of a glacier) and because this fluid permits the aforementioned minute and slow translatory movements of the grains the whole mass of ice is plastic. . . . This plasticity increases with pressure, hence with the increase in thickness of the glacier; on the sole of which truly immense pressures are effective in the direction of motion."—p. 82.

It will suffice for comparison to quote only one statement from the paper in the *American Journal of Science*[4] by the present author to show the close agreement with Hess's conclusions. ". . . the flow of glaciers . . . does not permit of characterization as either plastic or viscous. It is plastic flow in the sense that the ice mass as a whole is permanently deformed by the movement, but its component grains are not subject or capable of such plastic deformation except in one direction, and this appears to be a minor factor. Much more important is the movement that seems to be conditioned by the interstitial film of low freezing liquid, which may be characterized as a viscous movement."

Although Hess recognizes that the liquid film between the glacier grains is a salt solution and discusses the effect of the presence of the salts in the fluid on the growth in size of the crystals (p. 7), he misses completely the significance of the solution as a guaranty that a fluid lubricant is present throughout the interior of the glacier. This last condition was a chief point in the papers by the present author.

"An aqueous solution of sodium chloride will completely crystallize at its eutectic point $-22°$ C. . . . forming a mixture of salt and ice crystals, each distinct, in the proportions 23.5 per cent. NaCl and 76.5 per cent. H_2O. . . . As it is unlikely that so low temperatures as $-22°$ C. exist far below the surface in any glacial mass it is much more probable that liquid films of salt solution develop between the pure ice granules and that this salt solution is of a concentration, therefore, a thickness, dependent on the temperature and the size of the pure ice granules. Since . . . the temperature of the interior ice (is observed) to approach the pressure-temperature melting point it follows that the interstitial films of salt solution will be progressively thicker toward the lower end of the glacier."[5]

The above quotation, together with the one given in a preceding paragraph, are enough to permit appreciation of the correspondence of the two interpretations of glacier motion and of the special significance of the salt solution to the required lubrication for inter-grain shifts. They will also serve to make clear how different this concept is from the shear theory, in which it is postulated that glacier motion is: solid flow by idiomolecular exchange between ice crystals, solid shearing of aggregates of granules, intermittent slip along well-developed thrust planes and sliding of the whole body of ice over the rock beneath.

[4] P. 471, *op. cit.*
[5] *Am. Jour. Science, op. cit.*, pp. 464–465.

Such shear concept Hess, now, and the present author earlier, hold to be fundamentally and completely erroneous.

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ON THE GREAT ABUNDANCE OF THE BLACK WIDOW SPIDER

DURING this past summer, I have found the black widow spider (*Latrodectus mactans* Fabricius) quite common in the cities of Denver and of Boulder, and I have had reports that this species was quite abundant this year in Kansas, New Mexico and in Texas. In previous years, I have found these spiders in no small numbers under rocks and in protected sand banks in the prairies around Boulder and Fort Collins and in garages and basements in the outskirts of Denver. However, this is the first year that I have taken black widows in the center of the city of Denver, except on one instance when I captured a male in a centrally located high school on November 26, 1932.

While it is true that black widow spiders are more frequently observed this year because of wide-spread newspaper reports of their existence, I am convinced that the mild winter and very dry summer here in Colorado and elsewhere have favored their development and survival, since I find them more abundant in their natural habitat as well as in the city. Perhaps, one may account for their abundance in the city by the fact that they have come in to obtain moisture and to escape the drouth. In three blocks of the downtown district in Denver, I counted thirty-two black widow webs that were constructed, for the most part, in the corners of exposed walls of stores that were adjacent to the sidewalks. Contrary to popular opinion, I found most of the webs on the sunny side of the street.

This year I have found their webs in all sorts of situations. Some were constructed in sand banks that were exposed to the sun, others in the corners of chicken coops and rabbit pens, and still others on the undersides of plant tables in greenhouses. However, the majority of the webs were in basements and in garages. I found the most frequent prey to be grasshoppers, especially *Melanoplus bivittatus* Say. In fact, I counted the remains of eleven adults in one web that was constructed in a large trash receptacle. I have also noticed a marked decrease of other Theridiidae this year in the city. Possibly *L. mactans* is beginning to get the upper hand in the great struggle for existence.

ALBERT MILZER

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FRESHWATER MEDUSAE NEAR BUFFALO

FRESH-WATER Medusae were noticed for the first time in western New York on August 1, 1934. They occurred in a pond a few hundred feet from the shore of Lake Erie at Bay View, Lackawanna, a suburb of Buffalo, New York. They have been collected at intervals since from the same locality. The last date was August 28 when a few were taken all of which were of large size. About thirty, collected on August 17, were kept in an aquarium at the Buffalo Museum of Science for two weeks. At the end of this time they had all disappeared. The aquarium has been left undisturbed in the hope that eventually the hydroid form may develop.

IMOGENE C. ROBERTSON

GRANTS IN AID OF RESEARCH FOR 1935

AT the October meeting of the Executive Committee of the American Association for the Advancement of Science the customary allotment of $3,000 for the grants in aid of research was approved. All applications for consideration this year must be received by the Washington office before Thanksgiving. At the Boston meeting the recommendations of the Committee on Grants were approved. These provided for continuing the practise of previous years in giving small grants for the completion of important projects already initiated or supplying apparatus or facilities where adequate funds are not otherwise available.

The official year of the association extends from October 1 to the following September 30. All grants not utilized within the year revert to the treasury on October 1. Individual grants have regularly been limited to a sum less than $500, but the small sums have been useful in meeting emergency needs or such as are not covered by other agencies.

Applications are filed on special blanks furnished by the permanent secretary's office and considered only once annually. Applications should be supported by letters from at least two sponsors personally acquainted both with the applicant and with the project. These applications are handled by the committee of which the membership for the current year is as follows: Arthur H. Compton (1937) (for Physics), *chairman,* University of Chicago; Edward W. Berry (1936) (for Geology), Johns Hopkins University, Baltimore, Md.; William Crocker (1935) (for Botany), Boyce Thompson Institute, Yonkers, N. Y.; Philip Fox (1935) (for Astronomy), Adler Planetarium, Chicago, Ill.; Carl E. Guthe (1934) (for Anthropology), University of Michigan, Ann Arbor, Mich.; Samuel Colville Lind (1934) (for Chemistry), University of Minnesota, Minneapolis, Minn.; C. C. Little (1937) (for Zoology), Jackson Memorial Laboratory, Bar Harbor, Me.; Walter R. Miles (1936) (for Psychology), Yale University, New Haven, Conn.

The report of the committee is made annually to the council, which votes the allotments in December.

Payment of grants is made by the treasurer. Unused portions of grants should be returned on October 1 of each year.

Recipients of grants are expected to send to the permanent secretary's office at least one report during the fiscal year. Where results follow by reason of a grant, any publication on the subject should include due acknowledgment of the aid of the association.

HENRY B. WARD,
Permanent Secretary

QUOTATIONS

CONSIDER THE ANT

IF embryologists and evolutionists find it useful to correlate the structure and functions of man with those of lower animals, is there not reason to believe that something may be learned by comparing the social systems of men and insects? Professor William Morton Wheeler, of Harvard, does so in *The Scientific Monthly*, with results that would have pleased Dean Swift. Some 10,000 species of social insects are doing their best to set an example of loyalty, cooperation and devotion to the highest ideals. Some of these exemplars of correct social behavior began as long as a hundred million years ago to live in model communities. In comparison man is a mere upstart. His age is not more than a million years, so that his community life is but an expression of "social infantilism or immaturity."

If man is socially unstable, it is because of the "problem of the male," in Professor Wheeler's opinion. He is a restless, aggressive criminal. Such insects as the ants, bees and wasps settle the problem he presents by reducing him to futility and elevating the female. Woman reigns supreme among them—several kinds of women, in fact. The termites go even further. Keeping only a single monogamous male, they reduce the queen's offspring to sterility and set them "to work with their equally sterile sisters in the kitchens, dining rooms and nurseries, and at building and defending the termitary instead of permitting them to sit around like a lot of social parasites and annoy the females."

No well-disciplined, self-governing colony of ants or bees would tolerate the conduct of the human male. That worthy, as Professor Wheeler sees him, is forever killing something because he is hungry or because he likes to hunt; fighting with other males for a mate, or struggling for some selfish object. Wasps or bees would not even jail such a creature. They would kill him. From his anthropoid ancestors he has inherited intense egoism, pugnacity and the unsocial instincts that have always kept society in a state of turmoil. Professor Wheeler sees us confronted with a trilemma. We must find some means of socializing the large body of males that threaten to wreck civilization. Or we must return to a more unprogressive society resembling the termite state. Or we must lapse "into something like Spengler's Fellahin society." Professor Ernst Bergmann, of the University of Leipzig, agrees. Crush the male and save society is his formula. Go to the ant, consider her social ways and be wise.—*The New York Times.*

THE BIRTH RATE OF FRANCE

THE bureau of statistics has published a final report on the vital statistics of France in 1933. The general results are frankly unfavorable. There were 40,000 fewer births than in 1932, 200 more deaths and 600 more marriages. The excess of births over deaths was reduced to 21,600, as compared with 61,400 in 1932. The birth rate was reduced from 17.3 to 16.3 per thousand of population; the mortality remained stationary, and the number of marriages showed but slight variation (15.1, as against 15.0). The reduced birth rate is manifest chiefly in the southern departments of France. The central region shows little variation over the previous year. The excess of births over deaths is found chiefly in the departments of the North, West and East and has been so every year for a considerable period. It is surprising that the warmer regions of the South have fewer births, for Italy, under similar conditions, has an excess of births over deaths. In southern France, however, the population is less inclined to work hard. The people live a great deal in the open air and are fond of discussing, to little purpose, questions of politics, while the interest in religious questions is diminished. In place of industrial or agricultural work, they seek positions in the cities as employees or so-called civil servants. In this environment, increases in families appear to be less welcome. On the contrary, in the agricultural regions of Bretagne and Normandy, in which religious sentiments are more manifest and the interest in manual toil is greater, the families are larger. Children work in the fields at an early age. Similar conditions are found in the industrial regions of the North and the East, which are likewise more religious. In these regions school attendance is less rigorously supervised. The mayors of villages who have charge of school matters are inclined to permit peasants to keep their children at home for work in the fields. The conclusion is that the excess of births is in direct relation to the early use of the working power of the child and is in inverse proportion to school attendance, the progress of school instruction and interest in religion. Economic factors appear to be dominant. The number of children is evidently greater in regions where their services are profitable and is diminished in regions where their

presence is a burden on the family budget. The departments that have the most divorces have the smallest number of children per family. Widespread unemployment has caused many foreign workers to return to their own country, particularly the Poles and the Czechoslovakians, who came to France after the war. These foreign peasant families have always been more prolific than the French. The unchanging nature of the birth rate shows no improvement in spite of the development of the prophylactic services, the dispensaries and the hospitals.—*The Journal of the American Medical Association.*

SCIENTIFIC BOOKS

LIFE OF NEWTON

Isaac Newton, a Biography. By LOUIS TRENCHARD MORE. Pp. xii, 675. Charles Scribner's Sons, New York. $4.50.

THIS is an important and valuable book. Most of us get all that we know about Newton from Brewster's Life, and Brewster was so impressed by Newton's intellectual greatness and so desirous to present his character as without a flaw that he suppressed all evidence that had not already been made public which tended to show that Newton also had his human weaknesses and errors. A critical biography, in which all that can now be discovered about Newton is given its place and weight, has long been needed. This book supplies the need.

Dean More is eminently qualified for the task which he has now completed. He is a physicist of distinction, a widely read scholar, an acute critic, and, further, he is thoroughly in sympathy with Newton's philosophical method, which begins with experiments, proceeds by induction and makes no hypotheses.

Apparently all the sources from which information can be gathered about Newton's life and work have been examined. Some new matter has been introduced, such as the account of his first note-book as a schoolboy and some unpublished extracts from letters and private papers. But most of the details have been published elsewhere, either in biographies or in monographs. The peculiar value of the book depends upon the care with which all the available information has been collected and arranged, and the candor and impartiality with which controversial questions have been presented.

The events of Newton's life are not many, and recorded by themselves would be of little interest. Dean More has enriched the simple record by descriptions of the conditions in which Newton's life was spent, by accounts of the men with whom he came in contact and by elaborate dissertations on his work. Thus the fact that Newton was an undergraduate and later a fellow of Trinity College, Cambridge, is made interesting by an account of the customary curriculum pursued by an undergraduate and by a description of Trinity College. Newton's invention of a reflecting telescope introduces an account of the invention and development of the refracting telescope. The account of Newton's first communication to the Royal Society, in which he presents his discovery of the composition of white light, is followed by a chapter on Newton's theory of light and his philosophical method. The account of Newton's chemical work is accompanied by a justification of his having entertained the hopes of the alchemist. The description of the "Principia" is preceded by a chapter on the mechanistic hypothesis as it appeared in the thoughts of Newton's predecessors.

After the "Principia" was published the course of Newton's life changed and he was thrust into the arena of politics by the attack of King James on the freedom of the universities. To explain the course which Newton followed a full account is given of the political situation, so far as it affected the universities. Newton's famous mental disturbance after the intense strain of many years is carefully studied, and the conclusion is reached that it was a simple case of nervous breakdown, which released Newton's naturally suspicious nature and made him doubt the conduct of his best friends, while it did not impair his intellectual powers and passed away completely in the course of a year. For two or three years following Newton was occupied with the lunar theory, with a view to a second edition of the "Principia." He was suddenly called away from his scholarly seclusion by being appointed Warden of the Mint. He removed from Cambridge to London and devoted himself to his new duties, which were exceptionally important because he took office shortly after the great reform in the coinage had been begun by his friend and patron Montague, and when the mint was strained to the utmost to provide the new money. A full account of the monetary situation and of the general political situation as well is given to introduce the story of Newton's work. Not to mention many other instances in which the bare narrative is elucidated with historical or critical additions, reference must be made to the chapters in which Newton's controversies with Flamsteed and with Leibnitz are presented. His earlier controversies with Hooke were given in the chapters on light and on the "Principia." These controversies are examined with scrupulous fairness, and the conclusions that are reached may be accepted as final.

In the difficulties with Hooke, Newton comes off fairly well. Hooke was so irascible and so given to

making exaggerated claims of achievement which he was not able to substantiate that it is easy to show that most of his claims are without foundation. He did do a great deal in the study of the diffraction and interference of light, and Newton should have made a more complimentary and extended reference to Hooke's work than he did. Hooke's suggestion of the law of gravitation amounts to nothing more than a guess, and he never proved that his law could account for the planetary motions.

Newton's difficulties with Flamsteed, the Astronomer Royal, began when Newton asked him to furnish observations of the moon's positions. It appears from the record that Flamsteed furnished them as soon as he could and withheld none; but Newton complained to his friends that Flamsteed refused or delayed to furnish them. There was certainly delay in the development of the lunar theory, but apparently it resulted from Newton's procrastination rather than from Flamsteed's slackness. When the time came to publish the results gathered by Flamsteed in thirty years of observation, Newton was president of the Royal Society and controlled the committee which had the publication in charge. The history details a series of conflicts, in which Flamsteed's claims to the right to determine the main features of the publications were persistently ignored or overridden, and in which, apparently, agreements made by the committee and even by Newton himself were violated. Flamsteed was pertinacious and must have been irritating, but he seems generally to have asked for no more than his due. Newton's conduct seems inexcusable. We have no statement from him in justification.

The famous controversy between the Newtonians and the Leibnitzians as to whether Newton or Leibnitz first invented the differential calculus is given at length and with entire impartiality. There is now no doubt that Newton invented his method of fluxions several years before Leibnitz published his calculus. The evidence seems good that Leibnitz's invention was not based upon any hint which he received from the slight intimation which Newton had given of his method in two or three letters. Perhaps if the two principals had been asked, early in the discussion, before passions were aroused, to state on their honor what they had done and when they had done it, and to outline the course of thought which led them to their inventions, the full truth might have been known, due credit given to each and all controversy avoided. But such a course was not followed. Newton at first recognized Leibnitz as an independent discoverer, and Leibnitz admitted Newton's priority. But one of Newton's friends, irritated perhaps by the boasts of the Leibnitzians, accused Leibnitz of getting hints from Newton's work which led him to his discovery, and Leibnitz retaliated by hinting that Newton owed most of the development of the fluxional calculus to the model which Leibnitz had given him in his differential method. The quarrel dragged on for years. It is hard to decide which of the two principals was more unfair in his suspicion of the other, or which descended to the more unworthy methods of attack. Neither of them comes out, after a fair examination, free from reproach.

Unlike most of the biographers, Dean More, in detailing these controversies, has kept free from partisanship. Perhaps his judicial attitude was made easier for him because he had no national hero to defend. And yet it is hard for any English-speaking person not to feel a bias in favor of Newton. He is the crowning intellectual glory of our branch of the human family, and it hurts our pride in him to learn that he was suspicious and irritable, often on slight provocation, and implacable in his resentment when he felt himself offended.

An important chapter of the book is devoted to a review of Newton's work in chronology and theology. It is customary to depreciate this work as unworthy of so great a genius and even, as Biot did, to look at it as a result of his nervous collapse. But Dean More shows that such studies had occupied him from his early days and that some of his most important work had been done before his illness. It is shown, that, though his chronology is hopelessly wrong, the system which he proposed exhibits immense reading and great ingenuity. From some hitherto unpublished material we learn that Newton, as has often been suspected, was an Arian, though he had no scruples in maintaining his connection with the Established Church.

In the preceding paragraphs have been cited a few of the topics which Dean More has introduced in his book to elucidate the history of Newton's life. They are only examples of his method and indications of the wealth of scientific and historical learning which his book contains. He has accomplished a great work, and it may well be that he has written the definitive biography of Isaac Newton.

W. F. MAGIE

THE KINETIC THEORY OF GASES

The Kinetic Theory of Gases. By LEONARD LOEB. xi + 687 pages. Published by the McGraw-Hill Book Company, Inc., New York City.

THIS is the second edition of the well-known book by this author. The general style of the first edition has been maintained. The aim is apparently to keep the student interested at all costs and to lead him by successive approximations to the theory from the simple to the more complex. The factor of safety which the author has employed to insure success in

this direction is largely responsible for the great length of the book.

Besides the problems usually treated under the kinetic theory of gases there is included about fifty pages on specific heats and about sixty pages on electric and magnetic susceptibilities. These subjects are dealt with in a necessarily sketchy fashion, since they belong more properly in statistical mechanics. A most unusual feature of the book is the chapter of about one hundred pages on the subject of ionic mobilities on which the author is a distinguished authority.

Another novel feature of this book is the extensive use of the results of molecular beam experiments in discussing the basic questions of velocity distribution, low pressure and surface phenomena. There is unfortunately a serious slip on page 540, where it is stated that the magnetic deflection pattern has a maximum at a distance z_a. This maximum, as is well known, occurs at a distance more nearly equal to $(1/3)z_a$.

There are also extended changes in Chapter 5 on the "More Accurate Equation of State" and in Chapter 6 on "Transfer Phenomena" to include a treatment of molecular force fields. The changes have proved rather unfortunate, since they come at a time when the work of Massey and Mohr and of Uhlenbeck has shown that these considerations are quite inadequate and that the results of the quantum theory of collisions can not be neglected.

However, despite some defects this book remains one of the best to put into the hands of beginning students of kinetic theory.

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CYTOLOGY FOR STUDENTS

Introduction to Cytology. By L. W. SHARP. Pp. xiv + 567. McGraw-Hill Book Co. 1934.

THE third edition of Sharp's "Introduction to Cytology" maintains the high standards of the previous editions, which have made this book the leading text in its field. The subject is treated from the standpoint of cell structure and morphology, with emphasis on chromosome behavior in relation to genetics. A general description of cells and tissues is followed by several chapters on various cell constituents. A description of chromosome structure, chromosome morphology, mitosis and meiosis serves as an introduction to six chapters on the more important aspects of the new hybrid science, "Cytogenetics." These are followed by chapters on chromosomes and sex, apomixis and cytoplasmic heredity. A historical sketch of the development of cytology is presented in the last chapter, followed by an extensive bibliography.

The transfer of most of the literature citations to footnotes makes the references available without breaking up the continuity of the text. An outstanding feature of the book is the impartial treatment of controversial subjects. A good balance is maintained between facts and theories which should be stimulating without misleading the student. The emphasis on cytogenetics is in keeping with the numerous important contributions on chromosome behavior in relation to genetics, taxonomy and evolution. To students in these fields of biology, as well as to students of general cytology, Sharp's book is indispensable.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

ON THE CULTIVATION OF SEVEN SPECIES OF TRYPANOSOMES IN VITRO[1]

DURING the last five years the writer has successfully cultured the following species of trypanosomes on N.N. media.[2] One or two strains representative of each species have been maintained *in vitro* for periods of from nine months to over three years.

With some experience one can distinguish the cultural forms of certain species from the others herein reported, on the basis of their morphology and rosette formation as they appear when cultivated *in vitro* under identical conditions. Thus the individual cell, as well as rosettes of *Tr. duttoni,* differ from *Tr. americanum* and *Tr. avium.* The *Tr. americanum* in culture differs from that of *Tr. melophagium;* the former has its peculiar groupings and movements and the individual cells are relatively much larger, while *Tr. cruzi,* by virtue of its broad and slender forms, its movement and rosette formation, can also, at times, be distinguished from species mentioned above.

All species studied formed circular colonies on the slant portion of blood agar tubes. *Tr. americanum, Tr. duttoni* and *Tr. cruzi* colonized much sooner and more readily on this medium than *Tr. lewisi* or *Tr. rotatorium.* The latter species formed colonies only after several months' cultivation; however, once they commence forming colonies, afterwards they colonize readily. The colonies of *Tr. rotatorium* at times reached about 8 mm in diameter and closely resemble colonies of *B. megatherium,* while the colonies of *Tr.*

[1] From the Hygienic Laboratory, University of Michigan.

[2] F. G. Novy and W. J. MacNeal, "Contributions to Medical Research, Dedicated to Victor Clarence Vaughn," p. 549. George Wahr, Ann Arbor, Michigan, 1903.

TABLE I

The species of trypanosomes	The species of animal from which the trypanosome was isolated	Cultures: No. of days maintained *in vitro*	Cultures: No. of subcultures made
Tr. americanum (*Tr. theileri*)	Cows (Near Ann Arbor, Mich.)	1,010	61
Tr. avium (*Tr. paddae*?)	*Passer domesticus* (English sparrow)	868	42
Tr. avium (*Tr. noctuae*)	Screech owl	883	46
Tr. cruzi	From guinea-pigs experimentally infected with intestinal contents of *Triatoma Geniculata*	619	34
Tr. duttoni	*Mus Musculus* ("Common house mice")	231	14
Tr. lewisi	*Rattus norwegicus* (Laboratory white rats)	1,224	56
Tr. lewisi	*Rattus norwegicus* (Rats)	224	12
Tr. melophagium	*Melophagus ovinus* (Sheep keds)	375	28
Tr. rotatorium	*Rana pipiens* (American frogs)	834	44

americanum, *Tr. cruzi* and *Tr. duttoni* resemble more closely the *B. typhosus* colonies. Although the colonies resembled bacterial colonies, in all the microscopical examinations they revealed a solid mass of flagellates with healthy protoplasm. As a rule the individuals in the colonies were somewhat round and pear-shaped, but quite active, and those in the water of condensation were more active and usually had the morphology of crithidia or herpetomonas.

Infectivity and Spontaneous Attenuation of Trypanosomes in vitro

A strain of *Trypanosoma lewisi* (No. 201) was isolated on November 22, 1930, and was kept *in vitro* until the time of writing (March 31, 1934). Although this culture was infective for rats during its first few months *in vitro*, at the end of two years it had completely lost this power. Normal young rats were splenectomized and several cultures were inoculated in these animals, but no infection was produced. A recently isolated strain of *Tr. lewisi* cultivated *in vitro* for four months is still capable of producing an infection in rats. As a rule *Tr. lewisi* during its first year of subcultivation *in vitro* is infective for rats, but after about a year it gradually begins to lose this power. It is a definite fact that *Tr. lewisi* when kept in culture for two years on N.N. media is completely innocuous for rats.[3,4]

The initial culture of *Tr. cruzi* was obtained on July 20, 1932. After maintaining it *in vitro* for 468 days, it was inoculated into *Mus musculus*, into hairless *P. m. gambelii* (American deer mice) and into a guinea-pig. All these animals contracted the infection, trypanosomes were demonstrable in scanty numbers in their peripheral circulation and were recultured. Thus this species of trypanosome is still infective after 586 days' cultivation *in vitro*.

Tr. duttoni was cultured *in vitro* on March 2, 1933; 135 and 229 days after initial cultivation it was still infective to *Mus musculus*.

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AN ARTIFICIAL SYMBIOSIS

In order to keep tissue cells *in vitro* alive and healthy it is the practise of tissue culturists to renew the medium at frequent intervals. Such a procedure is supposed to increase the supply of oxygen and decrease the concentration of harmful by-products of metabolism. The three most common methods are: (1) Cutting out a fragment of tissue from the old culture and transferring it to fresh medium (usually a mixture of embryonic or other tissue extract and plasma); or (2) bathing the clot containing the culture in physiological salt solution (Tyrode's solution) for part of an hour, adding a small quantity of new medium before resealing; or (3) continuous perfusion of the culture chamber with a renewable fluid. Now if oxygen and food materials could be delivered to the very doorway of the cells and the by-products of metabolism be carried away, much as is done by the capillary circulation in the intact animal, there should be an improvement in health of tissues *in vitro*. Like the capillary circulation, the interchange should be continuous and relatively rapid.

There are many animals (protozoans, coelenterates, flatworms, etc.) which can live without feeding, provided they harbor green algae. The animal lives in the light, dies in the dark. The animal obtains carbohydrates and oxygen from photosynthesis and has its carbon dioxide and nitrogenous wastes removed. The alga gets nitrogen compounds and carbon dioxide from animal respiration. The common, unicellular green alga, *Chlorella*, is frequently found thus living symbiotically. A sterile culture of *Chlorella* grows very well on an inorganic salt agar medium.

Cultures were made combining the green algae with embryonic chick connective tissue cells and macre-

[3] F. G. Novy, W. B. Perkins and R. Chambers, *Jour. Infect. Dis.*, 11: 411, 1912.
[4] A. C. Behrens, *Jour. Infect. Dis.*, 15: 24, 1914.

phages. Control cultures were made of algae alone and others of chick tissue alone. Other cultures were made with amphibian cells instead of chick cells. The medium consisted of embryonic chick extract, chicken plasma and Tyrode's solution.

There was a very marked effect on the alga. In cultures containing algae alone, there was slow growth; the individual cells gradually became pale and the chloroplast appeared greatly shrunken. In the cultures of algae with tissue, the plant cells grew abundantly until there were numerous colonies. There was a marked difference, even here, between the algae immediately around the tissue and those a considerable distance away from the tissue. This was particularly true in the slow-growing amphibian cultures. Thus in cultures of adult amphibian heart, the algae became very dense about the beating heart, but showed little growth over the control in the periphery of the drop of medium. Not only did the algae multiply more rapidly in the mixed cultures, but they were larger, greener and the chloroplast did not shrivel up as in cultures of algae alone. The tissue cells grew around many of the algae colonies and individual cells. Many colonies were thus embedded in the tissue, and these remained green and increased in size, even through subcultures. Macrophages and fibroblasts took up algal cells in great numbers. Some of the tissue cells could be seen with included algal cells in all stages of disintegration, indicating digestion. It appeared that in some cases, after a macrophage accumulated a number of algae, it died, and the algae became a free colony, traces of the animal cell still adhering.

Macrophages engulfed algae in great numbers, and digestion probably occurred. These algae-filled macrophages seldom became fatty, as is characteristic of macrophages after a few days in cultures of tissues alone. The fibroblasts were also unusually devoid of fat. At the same time that the cultures of tissues alone showed almost every cell gorged with fat droplets, the cells of the cultures with algae rarely had fat droplets. In a few cultures in which there were algae on only one side of the explant, only the cells farthest from the algae produced fat. In rate of growth, as determined by increase in surface area, the mixed cultures were far superior to the cultures of tissue alone. Further, mixed cultures of algae and tissues grew and remained in a healthy condition for at least twice as long as cultures of tissue or algae alone.

Although it has not yet been demonstrated that the plant cells really do use the nitrogenous wastes and carbon dioxide of tissue respiration in vitro, it is true that they live and grow better under these conditions in the presence of animal cells. Similarly, although we have not shown that the animal cells really use the oxygen and carbohydrates produced by photosynthesis of the algae, it is true that they appear to be much healthier as evidenced by marked absence of fat and increased rate of growth (as increase in surface area). It is possible that the mutual benefit may be due to a decrease in toxicity of the medium, such as a mutual hydrogen-ion adjustment or a change in the physical structure of the plasma clot. However, we believe that whatever the mechanism, this is a case of an artificial symbiosis.

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PURE CULTURES OF PARAMECIUM

IN September, 1933, Glaser and Coria[1] described a method for the culture of *Paramecium caudatum* free from living microorganisms. The medium employed was a liver extract broth, into each tube of which was placed aseptically a bit of fresh unheated rabbit kidney and a suspension of heat-killed yeast cells. The medium was quite simple in composition and, for any one accustomed to working aseptically, easy to prepare. In May, 1934, Hetherington[2] reported that he had been unable to cultivate *Paramecium caudatum* free from bacteria in the medium of Glaser and Coria. In fact he found the medium as prepared by him toxic for *Paramecium*. He concluded that "Glaser and Coria probably did not have sterile paramecia."

Glaser has supplied me with three presumably pure strains of *Paramecium caudatum* and three of *Paramecium multimicronucleatum* growing in his medium. He also supplied some of the sterile medium which I used for transplants of the cultures. The cultures were examined microscopically, unstained and stained by various methods, for the presence of bacteria, but none were found. Detached cilia and certain needle-like crystals were easily distinguished from bacterial cells. All the cultures were inoculated onto the surface of slants of meat infusion agar, infusion agar plus ascitic fluid and Sabouraud agar, which were incubated at 22°C. and 37° C. aerobically and anaerobically. They were also inoculated into the depths of deep tubes of infusion agar and infusion agar plus glucose and ascitic fluid incubated at 22° C. and 37° C. These media were examined grossly and microscopically at intervals for two weeks and showed no evidence of growth of any kind. In transplants of the *Paramecium* cultures into the medium supplied by Glaser no evidence of toxicity was noted. All the cultures grew, and actively motile paramecia were seen for as long as two months after inoculation of the media.

[1] *Jour. Parasit.*, 20: 33, 1933.
[2] SCIENCE, 79: 413, 1934.

The cultures of *Paramecium* supplied by Glaser appeared to be pure and, in so far as could be determined, were free from living yeasts or bacteria. They multiplied and remained actively motile for two months in the medium of Glaser and Coria.

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SPECIAL ARTICLES

DETAILED SURVEYS OF SUBMARINE CANYONS

IN recent years the United States Coast and Geodetic Survey have constructed charts which make it possible to draw contours of submarine canyons off both the east and west coasts with a considerable degree of accuracy.[1] These charts, however, fail to give many of the fine points which are desirable in obtaining an accurate appreciation of the form of these canyons. For example, they do not give the data necessary to determine the exact slope of the walls and gradients of the floors, nor do they show whether the floors contain small basin depressions and whether the tributaries come in at grade as do the tributaries of land river valleys. In order to obtain this additional information the writer has made surveys in canyons near La Jolla and Carmel, California, which are from 10 to 20 times as detailed as any ever constructed by a coast survey party. Also, because of the methods used, somewhat greater accuracy of positions should have been attained than is possible in ordinary surveys.

This work involved no complicated mechanism and required only a rowboat, so that any one with a rudimentary knowledge of surveying and some simple equipment may make the same type of chart of any submarine or sub-lacustrian topographic feature which might interest them. In this machine age it may cause some amazement to state that neither were any motors used in the work nor would they have been of any material assistance. The modern method of echo sounding could not have been used, since it does not give accurate depths where steep slopes are involved, nor does the method allow a high degree of accuracy of location. Using a boat with an engine would not have given the maneuvering ability which is possible with oars and was vital to this type of survey. Also, since it was only necessary to pull in the sounding lead once or twice in an hour and depths did not exceed 1,000 feet, a hand reel proved quite satisfactory.

A range system of surveying was used (Fig. 1). Sextant angles give accurate locations at sea if angles between three or more land objects can be obtained. Where two of the objects are in range and thus only one angle is necessary a greater accuracy is obtainable than where two angles between the three objects are necessary. Also with a range it is possible through

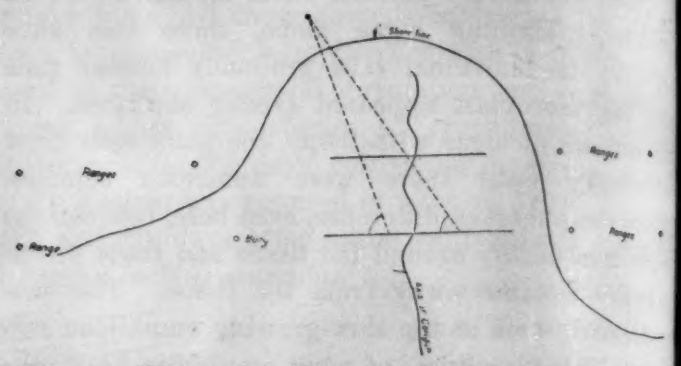

FIG. 1. Illustrating the method used in surveying the submarine canyons. Soundings were made at close intervals along these range lines and the exact positions obtained by taking angles to some shore object. In many cases it was not practical or possible to use ranges on both sides as are here indicated.

previous determinations to tell how much of a change of angle is necessary in order to move the desired number of feet for the successive soundings in running a cross section and furthermore the range makes the section a straight line. These ranges were developed before running the lines by using shore objects located at the proper positions or if necessary planting flags or even buoys.[2] While running each of the lines developed by these ranges it proved desirable to make many checks on the position of the line by taking two angles.

The soundings were made by running a wire with lead attached over the stern from the sounding machine and through a sheave hung from a small davit. The sheave had a depth indicator which operated like a speedometer. In making transverse sections of the submarine canyons the soundings were started on the shelf adjacent to the depression. After letting out the wire for the first sounding, it was not pulled in again, but the boat was rowed ahead trailing the lead and wire behind. Then before taking the next sounding the boat was backed till the wire became vertical and then the sounding made. Since most soundings showed an increased depth going down the side of the canyon the method was quite satisfactory and saved much time. Also in places where there were pinnacles or ridges on the canyon sides dragging the line served to detect their presence, where successive soundings might have straddled them. In a few places the lead caught on bottom and it was not always possible to free it, but this trouble was unusual, and out of almost 2,000 soundings off La Jolla not one lead was lost.

[1] The original survey sheets should always be used for this purpose, since they contain many more soundings than the published charts.

[2] A network of buoys may be used for this type of survey where it is run out of sight of land.

When the center of the valley had been crossed and soundings became shoaler, the lead was pulled in and the counter checked to see if the depth indications were correct. Then the boat was rowed over to the other side and the other half of the line was run in the same fashion. At the end of the second half of a line there was an opportunity to check the method at the point where the soundings crossed the same position as was obtained on the first half. Till some experience had been acquired it was sometimes found that the soundings did not check. This error was due either to the use of ranges which were either not sufficiently distinct or too closely spaced so that the boat could not be kept on a narrow line or it was due to insufficient backing of the boat before sounding to allow the wire to attain a vertical position. The use of a heavy lead helped eliminate the second of these sources of error and streamlining the lead proved to be some advantage.

The survey was carried on by a crew of three. One took the sextant angles and notes, the second took the soundings and the third rowed and kept the boat on range. The sextant reader increased the speed of operation and obtained some exercise by taking one handle when the sounding wire was reeled in.

Results of the Survey: It is not the purpose of the present paper to discuss the scientific results of these detailed surveys, but a few of the outstanding observations will be noted. Very steep slopes were found in both canyons, particularly in the one off La Jolla, where a maximum of 84° was measured on a 200-foot cliff. Outward from the canyon heads each section showed some increase in depth over those inside, so that no evidence of enclosed basins was discovered. Terraces, probably of rock, were found on the sides of the La Jolla canyon, and many ridges and hummocks of rock were detected on the sides of the Carmel Canyon. Tributaries entering at grade were found in both canyons.

Acknowledgments: These detailed surveys were made possible through the assistance of the Scripps Institution of Oceanography and the National Research Council. Most of the instruments employed were loaned by the Coast and Geodetic Survey.

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ACCESSORY HEARTS IN THE OYSTER

IN various animals, notably insects, certain blood vessels are specialized as pulsating organs which serve to pump blood into tissues either too distant from the heart to receive a rapid flow of blood or separated from the arterial system by capillaries. Such accessory hearts apparently have not been described in Lamellibranchs.

In oysters (*Ostrea gigas, O. virginica* and *O. lurida*) such structures may readily be studied, though they appear to have previously escaped observation owing to their location within the walls of the cloacal chamber. In a large specimen of *O. gigas* about 12 to 15 centimeters long they may be seen as a pair of elongated vessels on the inner surface of the mantle lobes which form the lateral boundaries of the cloacal chamber. At the posterior extremity of this chamber the two lobes of the mantle are united, forming a place of attachment for the posterior ends of the paired gills. The accessory hearts in a large specimen may be 2 to 3 centimeters long and extend from the kidneys (organ of Bojanus) almost to the posterior border of the cloacal chamber. At their distal ends each opens into the large blood vessel which runs completely around the corresponding mantle lobe. In the contracted state they have a diameter of about 1 millimeter, but when filled with blood they may be 5 millimeters or more in thickness. The pulsation consists of a wave of contraction beginning at the central, or kidney, end and traveling rather slowly distally.

The activity of these organs was best observed in specimens from which portions of the right valve had been removed, without damage to the underlying tissues. The border of the mantle grew back over the edge of the remaining shell, exposing the cloacal chamber and the accessory hearts. By looking through the cloacal chamber it was possible also to see the pericardium and count the beats of the heart. It was immediately obvious that the rhythmicity of the accessory hearts was entirely different from that of the heart itself, and that the two accessory hearts need not pulsate at the same rate.

The rate of pulsation of the three organs was measured by repeated successive counts of the time required for a given number of pulsations by each and the results for each organ averaged. A typical series averaged as follows: heart, 20.7 pulsations per minute; right accessory, 4.8 per min.; left accessory, 7.6 per min. Generally the left accessory beat more rapidly than the right, possibly due to the fact that the specimen lay in its left valve. It is probable that the rate of pulsation of the accessory hearts depends upon the rate at which they fill with blood. The above measurements show, at any rate, the independence of the three organs in initiation of pulsation.

Failure to observe the pumping activity of these organs has perhaps led to incomplete understanding of the circulatory system of at least some of the Lamellibranchs. These accessory hearts appear to be homologous to the gill hearts of Cephalopods, which are well known and which function to pump

blood from the spacious lacunae of the excretory organ to the gills. In this case their function is to complete the circulation of the blood which has lost arterial pressure after having passed through the lacunae of the viscera and into the excretory organ. In the oyster essentially the same condition obtains, save that, as in other Lamellibranchs, the mantle surfaces probably function largely in respiration, while the gills pump the food- and oxygen-bearing water. Thus the gills are primarily feeding organs, rather than respiratory. The gill hearts, in the oyster, pump blood into the highly vascular mantle, where aeration is accomplished, and also, through relatively small vessels, into the gills. The term, *gill hearts,* may be considered to apply to the oyster, in spite of these matters, because of homology with the Cephalopod organs.

The circulatory system of the oyster (*O. gigas*) consists of two parts, very incompletely separated. Blood from the ventricle of the heart is distributed through two large arteries: the posterior aorta, supplying chiefly the adductor muscle; and the anterior aorta, which runs forward, giving off branches into the visceral mass, and at the anterior end opening into a large vessel which divides both dorsally and ventrally into a pair of marginal pallial arteries which run completely around the border of each mantle lobe. That is, the dorsal pallial artery of each mantle lobe is continuous with the ventral pallial artery of the same lobe through the marginal artery. Venous blood from the adductor muscle and viscera is collected in the lacunae of the paired excretory organs, which apparently do not communicate directly with the auricles, as some investigators have thought. From the blood spaces of each kidney a large vessel, the accessory heart, pumps blood directly into the corresponding marginal artery, entering slightly anterior to the posterior insertion of the gills, along which runs a vessel connecting the two marginal arteries together and giving off branches to the gills. Thus the ventricle pumps blood into the marginal arteries from anteriorly while the accessory hearts pump blood into the same arteries near the posterior ends of the gills. The blood in the marginal arteries is subjected to pressure from two directions. In addition, the accessory hearts give off along their course small branches to the adjacent mantle.

The marginal arteries send out branches both distally and proximally into the mantle tissue and the blood is collected by lacunae and veins leading directly to the auricles of the heart. Veins from the gills also empty into the auricles. In this manner the blood returning to the heart, after aeration in the mantle and gills, consists in part of that which has been purified by the excretory organs and in part of systemic blood. The two communicating systems are readily demonstrated by injecting a colored fluid either into the ventricle, from which it goes throughout the marginal arteries, or into one of the accessory hearts, from which it goes into both of the marginal arteries and gills. The marginal artery, then, receives both arterial and venous blood, both purified (by the excretory organ) and unpurified blood.

It is considered possible that the accessory hearts described above may also be found in some other Lamellibranchs, though in most it would probably be difficult to observe the action of the organs.

A. E. HOPKINS

U. S. BUREAU OF FISHERIES

IS THE COLOR OF THE NATURAL RUBY DUE TO IRON?

IT is a well-known fact[1] that synthetic ruby must contain at least 1½ to 2½ per cent. chromic oxide in order to approximate the color of the natural gem; furthermore, it has already been shown[2] that there is not sufficient chromic oxide in natural ruby to account for its depth of color. The literature contains many analyses[3] of both natural and synthetic rubies which show that the two are chemically dissimilar; synthetic rubies contain chromic oxide but no ferric oxide, whereas natural rubies contain significant amounts of the latter in addition to the former; on the other hand, no distinction seems to be made between the two coloring agents in the naturally occurring mineral.

It was accordingly of interest to examine a number of natural rubies for the purpose of determining both the chromium and the iron content of the same specimen, of correlating their color with the amount of pigmenting oxide found and of deciding whether there is a definite ratio between the amounts of iron and of chromium oxides present.

After crushing the rubies to pass a 200-mesh sieve, and fusing them with potassium acid sulfate in the ratio of 15:1,[4] the iron was first separated by means of cupferron[5] and was ignited to the oxide. In order

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[5] O. Baudisch, *Chem. Ztg.*, 33: 1298, 1909; G. E. F. Lundell and H. B. Knowles, *Jour. Ind. Eng. Chem.*, 12: 344, 1920.

to check the quantitativity of the iron determinations in the presence of large amounts of aluminum and small amounts of chromium, known mixtures containing all three of these elements were prepared and analyzed. The iron was added from a previously standardized solution of ferrous ammonium sulfate, and the chromium was added as potassium chromium sulfate, to one gram of dry aluminum oxide or a proportionate weight of ammonium alum; in this way, mixtures were prepared in which the Al_2O_3 contained 0.5, 1.0 and 1.4 per cent. Fe_2O_3, with a constant 0.2 per cent. Cr_2O_3. When aluminum oxide was used, a fusion was made with potassium hydrogen sulfate in the ratio of 15:1; when ammonium alum was used, the same amount of flux was added without fusing. The results of these preliminary analyses are listed in Table I.

Spectrographic examination of the Fe_2O_3 obtained by precipitating once with cupferron showed the presence of small amounts of aluminum, which led to the high results shown in the second column of Table I; consequently, the iron had to be reprecipitated before final weighing. Reprecipitation was effected by washing the ignited precipitate into a beaker, adding 25 cc of concentrated sulfuric acid, heating until solution was complete, diluting and then precipitating again with cupferron in the usual way. This procedure gave the results listed in the third column of Table I; it was found that further reprecipitation does not change the results beyond experimental error.

TABLE I

RECOVERY OF IRON FROM MIXTURES CONTAINING KNOWN AMOUNTS OF ALUMINUM, CHROMIUM AND IRON

Gm Fe_2O_3 added	Gm Fe_2O_3 recovered	
	1st precipitation	2nd precipitation
0.0100	0.0130	0.0099
0.0100	0.0114	0.0102
0.0100	0.0118	0.0103
0.0140	0.0156	0.0140
0.0140	0.0189	0.0143

TABLE II

CHROMIUM AND IRON CONTENT OF RUBIES

Ruby no.	Place of origin	Chromium content		Iron content		Per cent. pigmenting R_2O_3	Color
		Per cent. Cr	Per cent. Cr_2O_3	Per cent. Fe	Per cent. Fe_2O_3		
1	Clay County, N. C.	0.136 0.139	0.201 0.203	0.44 0.44	0.63 0.63	0.83	Pink, translucent
2	Burma	0.207 0.212	0.303 0.310	0.36 0.36	0.52 0.52	0.84	Light red, transparent
3	Mica P. O., Transvaal	0.128 0.123 0.117	0.187 0.180 0.172	0.48 0.51	0.68 0.73	0.89	Pink, opaque
4	Zoutpansberg, Transvaal	0.130 0.131	0.190 0.191	0.86 0.82 0.83	1.23 1.17 1.19	1.39	Light red, opaque
5	Franklin, Macon County, N. C.	0.283 0.287 0.294	0.414 0.419 0.429	1.17 1.20	1.67 1.72	2.11	Deep red, transparent
6	Siam	0.327 0.329	0.478 0.480	1.16 1.16	1.66 1.66	2.14	Dark red, transparent
7	Mysore, India	0.162 0.156	0.237 0.228	1.76 1.76	2.52 2.52	2.75	Deep red, translucent
8	Vatomandry, Madagascar	0.204 0.196 0.204	0.298 0.286 0.298	2.19 2.25	3.14 3.22	3.46	Red, opaque

blood from the spacious lacunae of the excretory organ to the gills. In this case their function is to complete the circulation of the blood which has lost arterial pressure after having passed through the lacunae of the viscera and into the excretory organ. In the oyster essentially the same condition obtains, save that, as in other Lamellibranchs, the mantle surfaces probably function largely in respiration, while the gills pump the food- and oxygen-bearing water. Thus the gills are primarily feeding organs, rather than respiratory. The gill hearts, in the oyster, pump blood into the highly vascular mantle, where aeration is accomplished, and also, through relatively small vessels, into the gills. The term, *gill hearts,* may be considered to apply to the oyster, in spite of these matters, because of homology with the Cephalopod organs.

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[4] Wm. J. O'Leary and Jacob Papish, *Am. Mineral.*, 16: 34, 1931.

[5] O. Baudisch, *Chem. Ztg.*, 33: 1298, 1909; G. E. F. Lundell and H. B. Knowles, *Jour. Ind. Eng. Chem.*, 12: 344, 1920.

to check the quantitativity of the iron determinations in the presence of large amounts of aluminum and small amounts of chromium, known mixtures containing all three of these elements were prepared and analyzed. The iron was added from a previously standardized solution of ferrous ammonium sulfate, and the chromium was added as potassium chromium sulfate, to one gram of dry aluminum oxide or a proportionate weight of ammonium alum; in this way, mixtures were prepared in which the Al_2O_3 contained 0.5, 1.0 and 1.4 per cent. Fe_2O_3, with a constant 0.2 per cent. Cr_2O_3. When aluminum oxide was used, a fusion was made with potassium hydrogen sulfate in the ratio of 15:1; when ammonium alum was used, the same amount of flux was added without fusing. The results of these preliminary analyses are listed in Table I.

Spectrographic examination of the Fe_2O_3 obtained by precipitating once with cupferron showed the presence of small amounts of aluminum, which led to the high results shown in the second column of Table I; consequently, the iron had to be reprecipitated before final weighing. Reprecipitation was effected by washing the ignited precipitate into a beaker, adding 25 cc of concentrated sulfuric acid, heating until solution was complete, diluting and then precipitating again with cupferron in the usual way. This procedure gave the results listed in the third column of Table I; it was found that further reprecipitation does not change the results beyond experimental error.

TABLE I

RECOVERY OF IRON FROM MIXTURES CONTAINING KNOWN AMOUNTS OF ALUMINUM, CHROMIUM AND IRON

Gm Fe_2O_3 added	Gm Fe_2O_3 recovered	
	1st precipitation	2nd precipitation
0.0100	0.0130	0.0099
0.0100	0.0114	0.0102
0.0100	0.0118	0.0103
0.0140	0.0156	0.0140
0.0140	0.0189	0.0143

TABLE II

CHROMIUM AND IRON CONTENT OF RUBIES

Ruby no.	Place of origin	Chromium content		Iron content		Per cent. pigmenting R_2O_3	Color
		Per cent. Cr	Per cent. Cr_2O_3	Per cent. Fe	Per cent. Fe_2O_3		
1	Clay County, N. C.	0.136	0.201	0.44	0.63		Pink,
		0.139	0.203	0.44	0.63	0.83	translucent
2	Burma	0.207	0.303	0.36	0.52		Light red,
		0.212	0.310	0.36	0.52	0.84	transparent
3	Mica P. O., Transvaal	0.128	0.187	0.48	0.68		Pink,
		0.123	0.180	0.51	0.73	0.89	opaque
		0.117	0.172				
4	Zoutpansberg, Transvaal	0.130	0.190	0.86	1.23		Light red,
		0.131	0.191	0.82	1.17	1.39	opaque
				0.83	1.19		
5	Franklin, Macon County, N. C.	0.283	0.414	1.17	1.67		Deep red,
		0.287	0.419	1.20	1.72	2.11	transparent
		0.294	0.429				
6	Siam	0.327	0.478	1.16	1.66		Dark red,
		0.329	0.480	1.16	1.66	2.14	transparent
7	Mysore, India	0.162	0.237	1.76	2.52		Deep red,
		0.156	0.228	1.76	2.52	2.75	translucent
8	Vatomandry, Madagascar	0.204	0.298	2.19	3.14		Red,
		0.196	0.286	2.25	3.22	3.46	opaque
		0.204	0.298				

The excess cupferron was destroyed with nitric and sulfuric acids, and the chromium was determined by the procedure already described;[6] the method was then applied to a number of naturally occurring rubies. The results of these determinations are recorded in Table II. It is worthy of notice that ruby No. 1 was associated with fuchsite, and that ruby No. 8 occurred in diaspore with biotite.

A glance at Table II shows that there is no regularity in the ratios of Cr_2O_3 to Fe_2O_3; on the other hand, the depth of color in the ruby seems to be proportional to the total amount of coloring oxide present, listed in the last column of Table II, rather than to the chromic oxide alone. The values in the last column were obtained by adding the average percentage of Fe_2O_3 and Cr_2O_3 in each specimen, and are in remarkable agreement with what has already been stated regarding the amount of pigmenting oxide necessary to produce the typical color in synthetic ruby.

Work is now in progress in this laboratory on the synthesis of ruby, using ferric oxide alone as coloring agent.

SUMMARY

A number of specimens of naturally occurring ruby have been analyzed for both their iron and chromium content.

The total amount of coloring oxide in these rubies has been found to vary between 0.83 and 3.5 per cent.

The depth of color of the rubies analyzed seems to be directly proportional to the total amount of pigmenting oxide present, irrespective of the amount of chromic oxide found.

There is apparently no fixed ratio of iron to chromium in the rubies analyzed.

The total amount of pigmenting oxide found in the more deeply colored natural rubies coincides with the amount that must be incorporated into synthetic preparations in order to duplicate the color of the natural gem.

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THE MOLECULAR WEIGHT OF THYROGLOBULIN[1]

THE preparation of highly purified thyroglobulin[2] has made possible determinations of the molecular weight of this protein in the ultra-centrifuge.[3] Throughout the pH stability range from 4.8 to 11.3 the sedimentation constant, s, has been found to average 19.2×10^{-13} in the case of thyroglobulin prepared from hogs grown in the United States as well as in Sweden. The preparations were quite homogeneous and there was little non-centrifugable material. A sample of human thyroglobulin showed essentially the same sedimentation constant, although the preparation was not quite so homogeneous. At pH 3 on the acid side of the iso-electric point (which has been found to be at about pH 4.5 by Dr. Kai O. Pedersen[4]) hog thyroglobulin is incompletely split into two components, of which the lighter shows an s of about 11×10^{-13}. On the alkaline side of the stability range, at pH 12, there is also splitting into components of lower molecular weight. A sedimentation equilibrium run has indicated a molecular weight of about 700 000. From the sedimentation constant of 19.2×10^{-13} and the diffusion constant found according to the method of Tiselius[5] by Mr. A. G. Polson to be about 2.0×10^{-7} a molecular weight of about 800 000 is indicated. The partial specific volume has been found to be 0.72, an unusually low value for a protein. Additional data and a detailed discussion will be given in a later paper.

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[3] For review of method *cf.* T. Svedberg, SCIENCE, 79: 327, 1934.

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